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The Special Areas

Mr. P. M. Stewart, who resigned his office a month ago as Commissioner for Special Areas in England and Wales, has issued his third report. His appearance at the railway station to speed the marchers from Jarrow testifies to his sympathy for the human side of the problem of the special areas, although the Government appears reluctant to take any special step to deal with it. It probably hopes that the present revival of trade will filter through to these areas, even if the effect is felt later than elsewhere. The report recommends, among other things, the establishment of State-financed and State-controlled plants in the areas for extracting oil from coal, a calcium-carbide factory for South Wales, and the taking of steps to prevent Maryport harbour from becoming derelict. The Commissioner also points out the danger of the unrestricted growth of London, and says that in 1935 no less than 213 new factories were established in Greater London, representing 40 per cent. of the figure for the whole country, while only two, and six extensions, were recorded in the whole of the special areas. He proposes that London be placed out of bounds for further factory construction not essential to it, and that powerful inducements be offered to industries to settle in the special areas. He advocates relief from income tax on undistributed profits, with exemption below £500 per annum, relief from all local rates, and special long-term loans at low interest rates. These bold proposals may help where others have failed.

Perhaps the real trouble at the back of the difficulties of the special areas was touched on by Mr. Runciman, at the dinner of the London Iron and Steel Exchange, when he warned the iron and steel industry not to neglect export markets in its preoccupation with home orders. It is well known that the home trade revival is responsible for the major part of the present industrial improvement, and that some day the demand for capital goods must decline. We are essentially an exporting country, and must remain so. We are far from having recovered our old export business, and may never wholly do so; it is, however, important that we should do everything that is possible to regain it. The existence of a gap between the export trade we did and the export trade we do now is responsible for the difficulties of the special areas, and any alternative proposal may ameliorate but cannot wholly remedy their plight. Only by a revived export trade can we obliterate Sara, as the Special Areas Reconstruction Association has been dubbed. A valuable step forward was the recent agreement between this country, France and U.S.A. to co-operate in currency and exchange questions.

"Life"

After hearing the various authorities discuss the suitability of various words for describing the property which liquid metals have, in various degrees, of satisfactorily filling mould cavities, we are more than ever convinced that the most appropriate of all is "life." "Fluidity" is definitely inadequate because all fluid metals do not remain in this desirable condition for a sufficiently long time to fulfil their set purpose. The ideal metal for foundry purposes is one which remains fluid for a prolonged period, and this property is known, and always has been known, as "life." Cast iron has a longer relative "life" than steel. The "life" of a liquid metal may be defined as a summation of its fluidity properties throughout the casting period. The "casting period" is the time necessary for handling the liquid metal from the interior of the furnace to the freezing of the last mould to be filled. A metal having a good "life" will necessarily be the one which will properly fill a maximum number of moulds.

Mr. Stobie put forward the word "fluency," but we see no reason for adapting a word not normally used in this connection. If it be agreed that the French word *coulabilité*, a word translatable as "castability," is adequately expressive of the property under consideration, then we would point out that the first time we ever encountered this word was when in conversation with Mr. Ronceray, who used it as a French equivalent to our expression "life." We may be wrong, but we believe that *coulabilité* is just as much a coined word—coined by Mr. Ronceray—as would be *castability*, should such a horrible word ever permanently enter the English language. If a general consensus of opinion goes against us in our insistence on the adequacy of the word "life" and the word "fluidity" is to be used, then we would suggest that it be preceded by the adjective "overall," because a "fluid" leaving the furnace may easily merit the appelation "sticky" within an unreasonably short period of time. It must also be remembered that the spiral test was developed to measure this "range of fluidity," "overall-fluidity," or more simply the "life" of a metal or alloy, and not the fluidity at a given second.

Another way of regarding this matter is that the fluidity is an intrinsic momentary property of a metal or alloy which cannot be affected by external conditions, whilst the "life" is ameliorated or vitiated by such external conditions as mould dressings, and internally by abnormalities in the behaviour of the liquid metal or alloy.

Pattern-Making for Moulding*

By H. BRITTAIN

When making castings there are certain basic requirements which must be given every attention and careful thought. These can be enumerated as follow:—(1) The sand that is used to make the mould; (2) the correct type of pattern to make a suitable mould; (3) having good moulders to make the mould, and (4) satisfactory metal from which the ultimate castings are to be made.

Since each one of these points could be discussed at length, it is proposed to segregate the one which, whilst it is very important, is very often given the least thought, *i.e.*, the pattern and its production.

Good pattern-making is not necessarily the production of patterns that are pleasing to the eye when highly painted, but rather the production of patterns from which a good mould can be easily made, and which also are suitable for the methods employed in the foundry.

It is most important to know the methods employed by the foundry, because it is seldom that two foundries will use the same method of moulding the same job. It is necessary, therefore, for the pattern-maker to consult the foundryman as to the procedure he intends to adopt to mould the job in question. This is only necessary, of course, when the casting has not been made previously, or where it is obvious to the pattern-maker that the way he makes the pattern can have little or no effect upon the making of the mould.

The foundryman invariably wants to know the number of castings required before deciding on a method of moulding. For instance, if there be only one-off, he is prepared to use a skeleton or framed-up pattern, and use a pattern devoid of paint, fillet and many things which could make the pattern expensive if he insisted upon perfection in the pattern.

Skeleton Patterns

Naturally, the pattern-maker will make the cheapest job he can, and to do this skeleton patterns, illustrated in Fig. 1, are made. The lower pattern is for making an S bend pipe, and the pattern for the core plate, in front, and the strickle for the core will be observed. The construction of the pattern is obvious from the illustration.

If the S bend were much larger than 6 in. dia., the cost of pattern-making would be considerable, but the foundryman can make a loam block and super-impose wood flanges; hence the cost of the pattern is merely two flanges, one plate mould and two strickles, as is shown in Fig. 1.

The upper pattern in Fig. 1 is a junction for ducting. Here, again, the moulder is able to be of considerable assistance in keeping pattern-making to the minimum. Primarily, the pattern consists of a bottom frame, three flanges, two main struts and a series of intermediate oval stretchers to ensure a uniform shape.

Many other illustrations could be quoted where only one casting is required, the best known, of course, is when the casting required is circular; the obvious thing to do is to make strickles for striking up in either loam or dry sand.

Few-Off Jobs

The next consideration is when a nominal number of castings are required, say three to eight. In this case, the pattern-maker must make something a little more substantial to eliminate as much work in the foundry as possible. Fig. 2 shows a pattern of a gas burner body. It is of a shell construction, that is, the pattern is to all intents and purposes like the casting required. The only difference is that gaps, shown in the pattern, are actually metal in the finished casting.

The pattern is made in halves, which, of course, is essential, and is entirely of wood. It is naturally very frail; nevertheless, it has withstood being rammed up six times with little or no damage. The pocket on the left-hand side was also constructed to leave its own shape inside. It is certain that, had this pattern been made as a strong block, and the inside cored out by a corebox, not only would the cost have been considerable, but an exceptional amount of trouble would have ensued in trying to get the correct thickness of metal throughout. Moreover, it will be seen that in front of the pattern is the pattern for the core-iron. This was made in three sections; one for the main body and right-hand branch, the second for the branch directly facing, and the third for the pocket.

These sections each had one casting made from

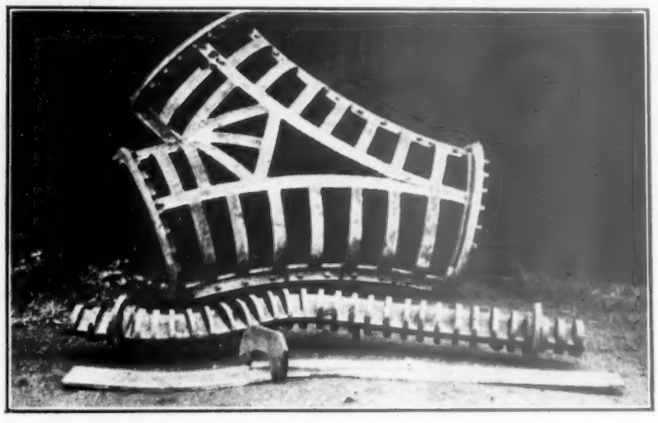


FIG. 1.—A GROUP OF SKELETON PATTERNS.

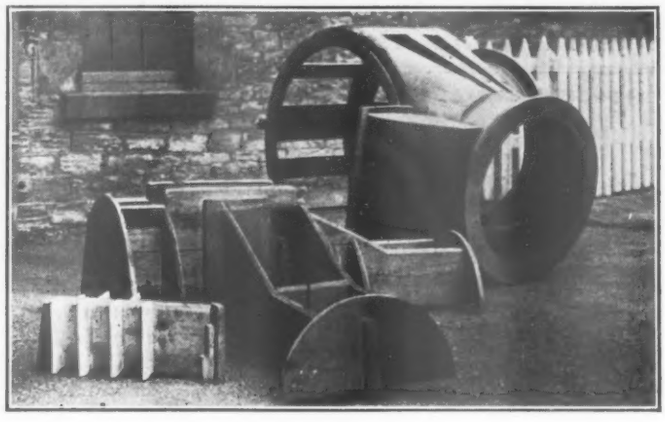


FIG. 2.—SHELL PATTERN FOR A GAS BURNER.

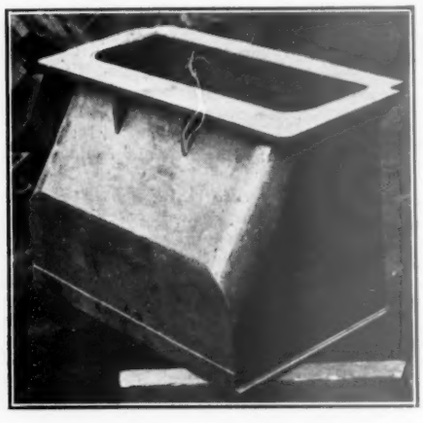


FIG. 3.—A SHELL PATTERN FOR A HOPPER.

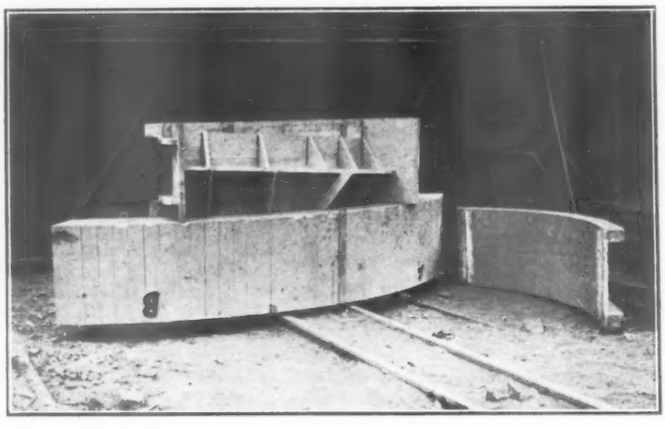


FIG. 4.—PATTERN FOR RING SEGMENTS.

* Entered in connection with a Short Paper Competition organised by the Sheffield Branch of the Institute of British Foundrymen.

them, and the castings were then bolted together to form one complete iron. By this means it was possible to dismantle this iron after use, and use it for an indefinite number of castings. The gaps shown in the body of the pattern were not to effect a saving, but to enable the moulder to ram through the pattern when bedding-in and when making the core.

A further example of making a shell pattern is shown in Fig. 3. It illustrates a hopper, the depth of which is 2 ft. 6 in. The major points to be noted are: (1) the thickness is only $\frac{5}{8}$ in.; (2) the sloping side, and (3) the large radius

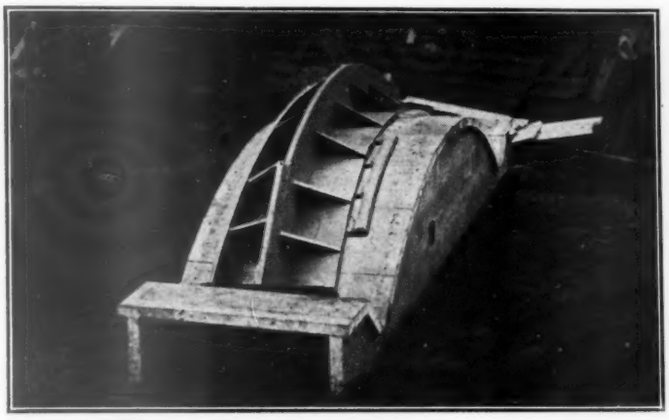


Fig. 5.—Ring Segment Pattern Mounted on Board.

corner. The top flange is loose. This wooden pattern requires a high standard of finish and construction, since ramming the inside alone is possibly sufficient to burst it asunder.

Another feature of this job is that there must be a reasonable amount of taper on the inside and outside, or it becomes impossible for the moulder to extract the pattern from the mould. Although this may seem elementary, it is astonishing the number of patterns one sees with little or no taper. It should also be noted that the construction of the pattern demands that the grain of the timber be against the draw, and therefore could be pulled apart.

Where there is a large number of castings-off, this type of pattern is made first in wood, and a casting made to use as a pattern. Hence, one can ensure rigidity and a good mould. Usually, however, the cost of making and preparing a

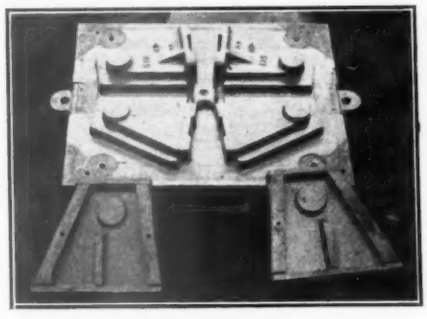


Fig. 6.—Multi-Job Pattern.

metal pattern is prohibitive, and in many cases it is much better to make an extra wooden one. It might be asked why the inside could not be cored out. It is the practice of the author's firm to make these castings in green sand, and the method employed in making the pattern is one necessary to suit the foundry.

Ring Segments

Figs. 4 and 5 are of patterns for some large ring segments. The approximate length is 9 ft. and every segment in the ring is varied. Owing to the number of castings required and the difference in each, it was decided to make a segment block. Since the segments tapered on one edge from end to end and were continuous from one segment to the next, it was possible to make the block constant for each casting. The corebox was a frame equal to one half of the block. Inside the corebox, the equivalent of one half of the required segment was superimposed. This will be clearly seen in Fig. 4, where the corebox is mounted on top of the pattern. Then from the second core suitable alteration pieces were made to fit in the same corebox frame, thus completing one segment. Each ring consisted of four segments; thus it was necessary to make four sets of alteration pieces, and by reversing each piece after making one core, it was possible to make the core for the opposite side.

This method was quite satisfactory for slow production, but, when it was found necessary to produce the castings at a much faster rate than was anticipated, it was decided to make another pattern. The question was raised as to whether the pattern had been made to facilitate the quickest method of moulding, for it was obvious there was at least one other way of moulding this particular job. It could be moulded with the arched surface reversed, and in the bottom of the mould, whereas before this was moulded on the side. It was also decided to use no cores, which meant that a pattern had to be made exactly like the segment casting required. Since each segment was different, the question to consider was how to make a suitable pattern.

To achieve this end, a curved plate-pattern was made a constant width, with loose pieces for the tapered edge. The narrow flange, as seen on the left in Fig. 4, was a fixture; the wide flange and ribs were made loose, so that they could be altered to make another segment. Then by cutting some of these parts and renewing others it was possible to make one pattern suitable for each complete ring.

This method did not provide a pattern that would withstand much ill usage and still retain its exact form, therefore it was necessary to provide a ramming board on which to mount the pattern during the process of ramming the bottom part of the mould. This board is plainly

Fig. 7.—Pattern and Corebox.

discernible in Fig. 5; it will be noted that the runner was made permanent. As a ramming board was used it was necessary to make special box parts for the job. These could have involved a large expense in pattern-making, but to obviate this one pattern was made for the side of the bottom part, one for the top part, and one end for the bottom part, which could be cut down to make the end of the top part. From each of these patterns two castings were made, which were eventually bolted together to make the boxes.

On the left of Fig. 5 is shown part of the bottom portion of the moulding box containing the casting. Whilst these two moulds are so

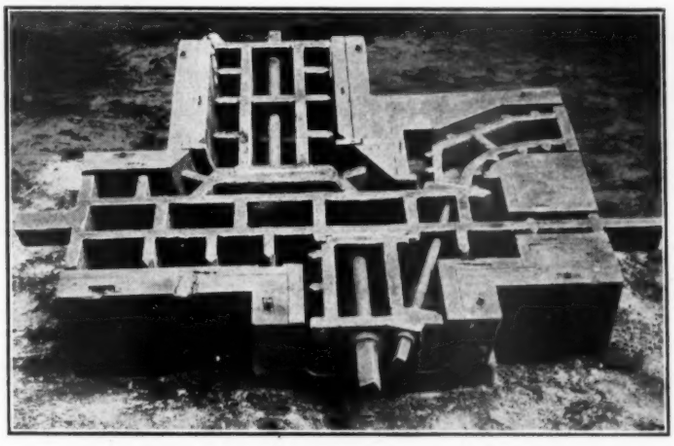


Fig. 8.—Corebox with Taper Provision.

widely different, it is questionable whether anyone would decide which was the better and cheaper of them.

Patterns for Large Numbers

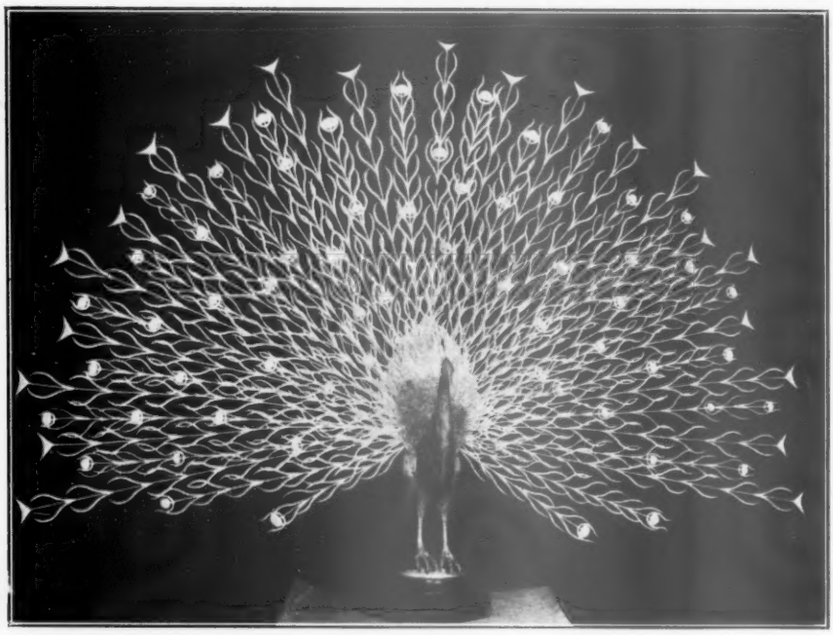
It is now proposed to deal with the case where, say, 200 or more medium-sized castings are required. Usually the first thing that comes

(*Concluded on page* 388.)

Aluminium for Art Metal Work

EXAMPLES OF ITALIAN CRAFTSMANSHIP

In general, too much appreciation is given to ancient art and too little approbation meted out to living artists. Below we illustrate examples of the work of Coletti, the Italian master smith. He works in aluminium on account of its lightness and lustre. It is capable of being beaten into lamellæ and responds to the delicate touch of the artist's chisel. As it does not corrode when away from the sea coast, and is not subject to excessive tarnishing, it has much to commend it to the artist. The examples shown below were recently exhibited in New York and have been photographed by Foto Luxardo, of Rome. These pictures show the sympathetic manner in which aluminium has been treated, together with the technical skill displayed in the execution, and they constitute an unusual example of what a skilled artisan can do. Each part is delicately chiselled, twisted and hammered to its required form, and then welded to its companion unit. The patience and amount of labour entailed in developing the minutely worked tail feathers of the peacock can readily be appreciated. This welding process, incidentally, requires expert knowledge and craftsmanship, for there is a narrow zone of temperature required.



THE MIRRLEES WATSON COMPANY, LIMITED, Glasgow, have concluded an arrangement with the Gill Propeller Company, Limited, London, whereby they are licensed to manufacture axial-flow pumps to the design and patents of the Gill Propeller Company.

Pattern-Making for Moulding

(*Concluded from page* 387.)

to mind is "multiple moulding," either by hand moulding or machine. In Fig. 6 is shown a pattern plate made of wood with reinforced corners and cast-iron lugs bolted in position. Four half patterns of a bracket, mounted symmetrically from the centre line of the lugs in each direction, will be noticed. It will be obvious that two parts, moulded from this plate, when put together, will produce four castings. The runner is made on the plate, thus saving moulder's time, and the main feature about these plates is that the patterns must be definitely accurate and mounted perfectly. One other necessary point is that there must be a reasonable amount of taper on all parts.

This pattern plate was used for hand moulding, but it can also be used on a machine. The circular plates seen in Fig. 6 are bushings for the purpose of bolting on to the machine plate.

Machine Moulding

The next consideration is machine-moulding practice; not for the purpose of multiple moulding, which, of course, is quite straightforward on any type of moulding machine, but its application to one job only to speed up its production. This pattern (Fig. 7) was originally loose and moulded in green sand. The under-side was hollow and made its own core, and was a very unsatisfactory method. The new pattern was made in mahogany to withstand the jolting and constant use. The inside was cored out in four sections.

The corebox and its core are clearly shown in Fig. 7. Owing to the print for this core overhanging the inner and outer diameter of the actual casting, it was possible to put the four cores in the bottom part of the mould, thus making the job very simple for moulding. Here again the runners are an integral part of the pattern. The pattern plate is similar to the one shown in Fig. 6, but much larger. Fig. 8 illustrates a corebox. In this case the sides of the core must be definitely square with the base. Therefore, the pattern-maker had to provide for this, and the method adopted was to make the corebox each side about 2 in. larger than was required; loose pieces with an excessive amount of taper on the back were then inserted.

The author is convinced that more and more does the pattern shop become a service department for the foundry where progress is the predominant feature.

Second Report of the Steel Castings Research Committee

BY A JOINT COMMITTEE OF THE IRON AND STEEL INSTITUTE AND THE BRITISH IRON AND STEEL FEDERATION

(*Continued from page 379.*)

SECTION IV.—The Strength and Ductility of Cast Steel during Cooling from the Liquid State in Sand Moulds

(*Abridged.*)

By H. F. Hall, B.Sc., A.M.I.Mech.E.
(Research Department Woolwich).

The stress to which steel castings are subjected by contraction on cooling in the mould is a determining factor both in design and in the methods employed for moulding and casting, but means for ascertaining the strength possessed by the metal under such conditions are at present confined to an interpretation of the results of the examination of castings after removal from the mould.

The stress which determined whether a casting fails is influenced by many variable factors, and the ability of the metal to withstand it without failure cannot be assessed in terms of its own strength under one set of conditions. Both the strength and stress vary continuously with temperature, and a temperature distribution differing slightly in two similar castings may in one of them create an excess of stress over strength at a critical period of cooling, leading to failure, and in the other preserve throughout the necessary excess of strength. Stress is also influenced by the ductility existing locally and in remote parts of the casting; variation of ductility with temperature is, therefore, important in determining the incidence of local failures.

To obtain results of value it is essential that the tests should be unaffected by any reheating treatment, and they should therefore be made under natural conditions of cooling in the mould. Accordingly, special apparatus has been devised for making rapid determinations of the strength and ductility of castings under the required conditions. The temperature gradient in the cross-section of the test-piece, although undesirable in normal testing procedure, is characteristic of all parts of a casting when cooling, and any effect it may have on strength properties is taken into account in the results of these tests.

Briefly described, the procedure consists of casting a group of test-bars simultaneously in one mould and subjecting each in succession to a tensile test. The times chosen for the tests control the temperature at which each is performed. With prior knowledge of the rate of cooling the tests can be made at a predetermined series of temperatures, with the first as near as may be desired to the point of solidification.

Preliminary Experiments

The practicability of such tests was confirmed by experiments carried out with improvised means. The lift of an overhead travelling crane was used for exerting the pull on each test-piece, the mould being held down by dead weights. Six vertical test-bars 1 in. in dia. and gated near the lower end were cast through a central down-runner on to bolts fixed to the base of the moulding box. The upper ends of the bars were cast on to rings set in the top of the mould to enable the crane hook to be attached.

After removal of the ladle the first test-piece was connected to the crane hook and broken. The breaking load was measured by the ball impression produced by transmitting the pull of the crane through a pair of stirrups, one carrying a steel ball resting on a polished steel plate carried by the other. For the second and subsequent tests the crane hook was transferred successively to the other test-bars, and the polished plate was moved in the stirrup to isolate each impression. The plate bearing the impressions was subsequently calibrated with the same ball in a Brinell machine.

Temperature measurements were made on a separate casting of a single test-piece of the same size. A platinum/platinum-rhodium thermocouple in a two-bore fireclay insulator was arranged to project into the mould, the hot junction was exposed on the axis of the test-piece, and was cast solid with the steel. Temperatures were taken at measured intervals of time after pouring. The results of some of these tests are given in Table I. They show the general absence of reduction of area above about 1,300 deg. C., and the attainment of appreciable ductility below 1,250 deg. C.

Table I.—*Preliminary Tests on 1.0 in. dia. Castings. Straining by Crane, and Load Measurement by Ball Impression.*

Rate of strain (approx.), 8 in. per sec. Length of test-pieces, 12 in.

Casting No. 4. Carbon 0.45 per cent.						
Time after pouring, sec.	30	45	60	75	90	105
Temp. from cooling curve, deg. C.	1,360	1,315	1,250	1,210	1,160	1,120
Ultimate stress, tons per sq. in.	0.4	1.0	1.2	1.9	2.4	2.6
Reduction of area at fracture, per cent.	Nil	Nil	10	19	28	36
Casting No. 7. Carbon 0.33, nickel 3.1 per cent.						
Time after pouring, sec.	39	52	60	85	96	—
Temp. from cooling curve, deg. C.	1,330	1,270	1,250	1,170	1,130	—
Ultimate stress, tons per sq. in.	0.3	0.56	0.76	1.7	> 2.1	—
Reduction of area at fracture, per cent.	4	Nil	8	34	Unbroken	—
Casting No. 8. Carbon 0.30, silicon 0.9, nickel 0.5 per cent.						
Time after pouring, sec.	42	52	63	75	91	103
Temp. from cooling curve, deg. C.	1,320	1,270	1,240	1,210	1,160	1,120
Ultimate stress, tons per sq. in.	0.4	0.9	1.00	1.35	1.8	2.2
Reduction of area at fracture, per cent.	Nil	2	6	13	9*	15*

* Cavities 0.25 to 0.30 in. in dia. at fracture.

Mould Design

Experiments were continued with moulds designed for use with apparatus then under construction. In these the down-runner was transferred to the side of the box to allow connections to be made for all the test-pieces before pouring. The mould shown in Fig. 1 provides for twelve test-pieces of 0.625 in. dia.; a similar mould accommodates eight test-pieces of 1.0 in. dia.

The designs of test-piece and methods of gripping shown at A to E in Fig. 2 were found unsatisfactory for the following reasons:—

Test-piece.	Remarks.
A.	Failed by contraction pull between the shoulders before the lower temperatures were reached.
B.	Conical form of bolt head gave unsoundness.
C.	The unsoundness was confined to the enlarged section, but the temperature gradient became unsuitable. Fracture occurred in enlarged portion.
D.	Mass of metal reduced at lower end. Fracture occurred in upper shoulder.
E.	Similar method of gripping at both ends. Equal tendency to fracture at either end rather than in the middle.

The best results were obtained by making the test-pieces parallel throughout their length, as shown at F, and obtaining the necessary grip by casting on to screw-threaded bolts of smaller diameter than the test-pieces. The upper bolt was held in position by a separate tapered core fitting in the mould and loaded externally to prevent rising under the pressure of metal when poured. This form of test-piece proved satis-

Table II.—*Strength and Temperature Accompanying 5 per cent. Elongation at Fracture.*

Rate of Strain, 0.21 in. per sec.

Casting.	Composition. Per cent.	Ultimate stress. Tons per sq. in.	Skin temperature. Deg. C.
PRF	0.04 C	< 0.12	> 1,405*
PAK	0.10 C.	0.23	1,405
PRD	0.14 C	0.56	1,360
PRE	0.20 C	0.85	1,280
PAM	0.25 C	0.92	1,295
OWO	0.26 C	0.86	1,290
OWM	0.37 C	1.16	1,285
OEL	0.39 C	0.88	1,270
PAN	0.42 C	1.11	1,270
PAO	0.87 C	0.97	1,220
OWV	0.14 C, 1.25 Cr	0.92	1,315
OWK	0.19 C, 2.0 Mn	0.84	1,310
OWZ	0.33 C, 0.25 V	1.07	1,275
OWQ	0.39 C, 1.0 Ni	—	1,275
OWS	0.21 C, 3.1 Ni	0.63	1,270
OWT	0.20 C, 5.0 Ni	1.02	1,270
PAQ	0.27 C, 0.3 Mo	1.15	1,265
PER	0.30 C, 2 Ni, 18 Cr	1.03	1,255
OWR	0.42 C, 3.45 Ni	1.01	1,245
PEQ	0.33 C, 2 Mn, 0.3 Mo	1.10	1,230
PAL	0.15 C, 8 Ni, 18 Cr	1.26	1,230

* This steel gave 17 per cent. elongation with skin temperature 1,406 deg., core temperature 1,460 deg. C.

factory for casting, gripping and the location of the fracture, but the test result was subject to error due to the inclusion of frictional resistance between the mould and test-piece in the load measured.

This defect was eliminated in the design of mould ultimately adopted, details of which are given in Fig. 3. It required from 25 to 30 lbs. of steel, and there was provision for eight test-pieces 1 in. in dia. One test-piece was left undisturbed throughout the test, for recording the temperature; two thermocouples set in a sand

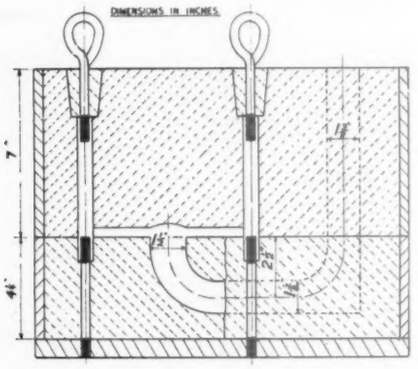


FIG. 1.—MOULD FOR TWELVE TEST-PIECES.

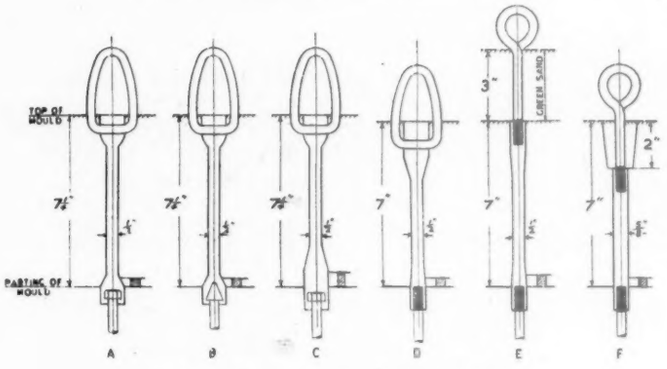


FIG. 2.—SOME EXPERIMENTAL FORMS OF TEST-PIECE.

plug, the inner face of which was moulded to the test-piece contour, were inserted in the side of the mould and provided for simultaneous records of axial and skin temperatures.

All other test-pieces were cast in separate cores. These were tapered on the outside to make an easy fit in the mould, and fitted with an eyebolt at the upper end. When the test was performed the sand core broke at the same position as the test-piece and the upper portion was freely drawn from the mould with the test-piece enclosed. The sand core was weakened by burning of the oil bond by the steel, and did not appreciably affect the load; if the steel be slightly ductile the core must break before the maximum load is attained, when it can have no effect on the value recorded.

The test-pieces were moulded with their axes inclined to the vertical to coincide with the axis of pull during test. Accurate alignment and spacing of the patterns during ramming was obtained with the aid of a dowelled ring. Twelve 0.625 in. dia. test-pieces were accommodated in a similar type of mould.

The sand used for making the moulds consisted of equal parts of Cumberland red sand, Leighton Buzzard medium, and Erith fine silica sand with 6 per cent. by volume of oil binder.

CONCLUSIONS

Influence of Composition on Tensile Strength

The rate of increase of strength was generally lowest during the early period of test, with strength below 0.4 ton per sq. in., and before the temperature had attained its maximum rate of fall. The 0.1 per cent. carbon steel, which developed early ductility, increased in strength at a uniformly high rate. In fact, at a given high temperature the strength of a carbon steel diminished with increase of carbon above 0.1 per cent.; but if allowance was made for the lowering of the solidus temperature, the gain in strength on cooling through a definite temperature interval below the solidus was rather more in high- than in low-carbon steels. The variations in strength obtained with small alloy additions were within the limits of those produced by variation of the carbon content in plain carbon steels.

Comparative values determined with rates of strain of 0.046, 0.21 and 1.0 in. per sec. are available only for the 0.3 per cent. carbon steel. With the slow rate of strain 0.4 ton per sq. in. was attained at the same temperature as with the medium rate, but 0.7 and 1.0 ton per sq. in. were recorded at temperatures about 50 deg. C. and 100 deg. C. respectively lower than with the medium rate of strain. At the high rate of strain the temperature for each stress was about 25 deg. C. higher than that for the medium rate of strain.

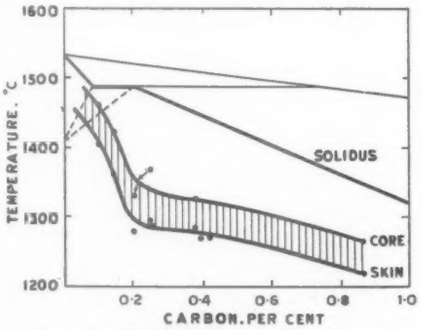


FIG. 4.—TEMPERATURE OF TEST-PIECES GIVING 5 PER CENT. ELONGATION.

Influence of Composition on Ductility

At temperatures above 1,300 deg. C. ductility was found only in steels containing less than 0.2 per cent. of carbon, and with the exception of these and some alloy steels mentioned later the lowest ultimate stress accompanying ductility was 0.8 ton per sq. in.

The appearance of ductility, except in the low-carbon steels, occurred after the rate of increase of strength and fall of temperature had attained their maximum values, and the limits of stress and temperature between which this occurred vary but little in a wide range of compositions. No stress greater than 1.0 ton per sq. in. and no temperature lower than 1,250 deg. C. was recorded without some elongation. The main distinguishing feature between different steels was the rate at which elongation increased with further fall in temperature.

As it is difficult to judge with accuracy the temperature of the first appearance of ductility, the strength and temperature accompanying 5 per cent. elongation at fracture have been taken as an indication of the relative conditions under which ductility appeared in the steels tested; the steels are compared on this basis in Table II. With carbon not higher than 0.1 per cent., the temperature was above 1,400 deg. C. The 0.14 per cent. carbon steel (*PRD*) possessed a strength of 0.56 ton per sq. in., with 5 per cent. elongation; in the absence of a temperature record the temperature is estimated at about 1,360 deg. C. In medium-carbon steels (0.2 to 0.4 per cent. of carbon) the temperature fell to the range of 1,295 to 1,270 deg. C. before 5 per cent. elongation occurred at fracture. For similar elongation in the 0.87 per cent. carbon steel (*PAO*) the temperature had fallen to 1,220 deg. C. with a stress of about 1 ton per sq. in.

These values for steels of different carbon contents are plotted in Fig. 4, in relation to the liquidus and solidus temperatures of the iron-carbon alloys. The corresponding values of the temperatures at the axis of the test-bars are also included. It will be seen that, whether these or the skin temperatures are considered, there is a considerable range below the solidus temperature before appreciable ductility (*viz.*, 5 per cent. elongation) is attained, and that this range is greatest for a 0.2 per cent. carbon steel.

Nickel up to 5 per cent. or small additions of chromium, vanadium, or molybdenum in 0.2 to 0.4 per cent. carbon steels had no appreciable effect on the temperature, which fell to about 1,270 deg. C., as for the carbon steels, before

(*Concluded on page* 392.)

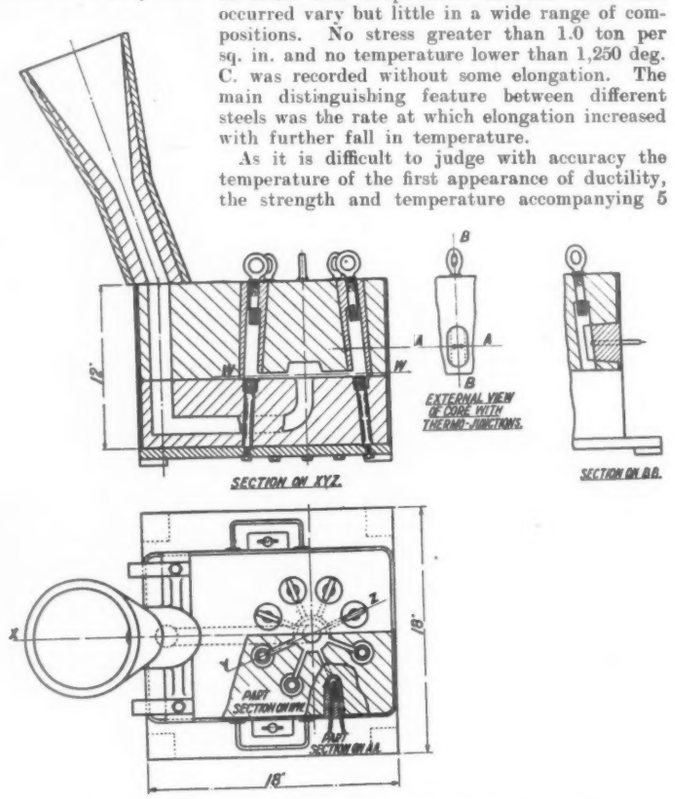


FIG. 3.—MOULD FOR EIGHT TEST-PIECES CAST IN CORES.

Sand Castings of Copper-Silicon Alloys*

By H. A. BEDWORTH and V. P. WEAVER

(Slightly Abridged.)

The increasingly widespread use of copper-silicon alloys in many important fields of industry has made necessary an understanding of their casting technique in the non-ferrous foundry. This Paper will describe the methods used in the production of copper-silicon alloy sand castings and indicate that this comparatively new group of alloys is responsive to application of the various well-known fundamental principles of foundry practice. An outline will be given covering the melting, moulding and pouring of the alloys, followed by a brief summary of their properties and uses.

Metallurgists have devoted much time and study to the possibility of substituting other metals for tin in the older and better known bronzes. The copper-silicon group is an outstanding example of this development brought about by a decrease in the world's visible supply of tin and the high price of this metal. The alloys are principally copper alloyed with silicon plus one or more additions to enhance their other properties, particularly those which render them especially suitable for the manufacture of castings. Silicon occurs mainly in the form of its oxide, silica, or as a constituent of silicates, these forms being more familiarly known as sand or rock. Commercially pure silicon is reduced from these compounds.

Castings of copper-silicon alloys are specified by the U.S. Navy Department in its specification 46B28 and by the Federal Specifications Board in its specification QQ-C-593 as follows: Si, 1.00-5.00; Mn (max.), 1.50; Zn (max.), 5.00; Fe (max.), 2.50; Sn (max.), 2.00; Impurities (max.), 0.50 per cent., and Cu remainder.

The important alloying agent is silicon, which enters into solid solution with copper and hardens and strengthens it at a much faster rate than the common metals such as nickel, zinc, tin, and aluminium. The metallography of some of the alloys is described by Smith.† Although a wide range of composition is permitted by the Government specifications and the silicon limits are especially broad, the alloys which are supplied for foundry use contain usually from about 3.5 to 4.5 per cent. silicon. Because of the great hardening power of silicon, the wider limits of Government specifications would permit alloys of greatly varying physical properties, and the minimum physical requirements of the specifications have therefore been set at 20 tons per sq. in. tensile strength and 15 per cent. elongation in 2 in.

The development of the alloys has proceeded under patent protection and the marketing has been carried on through the use of proprietary names. The authors have had experience principally with the nominal composition, 95 per cent. copper, 4 per cent. silicon, 1 per cent. manganese, which has been in commercial use for sand casting for the past 10 years.

Melting Practice

Copper-silicon alloys come to the foundryman in notched ingot form ready for use, and can be melted and cast with the regular equipment of brass and bronze foundries. The use of deoxidising agents is not necessary during the melting to produce good castings. The alloys are successfully melted in crucible furnaces, fired with anthracite coal, coke, oil, or gas, or in electric furnaces. It is advantageous to maintain a neutral or slightly oxidising atmosphere. A reducing atmosphere brought about by insufficient air supply, causes incomplete fuel combustion, and results in a tendency for the alloys to absorb unburnt furnace gases which are expelled while freezing of the metal takes place. Spewing and gas porosity are almost certain to be the result.

To protect the metal during melting it is usually recommended that a layer of some gasless flux be used, such as ordinary bottle glass. While it is possible to use charcoal as a cover, it is not considered advisable because of the strong tendency of charcoal to absorb moisture and gases which, if not burned, may cause porosity in the alloy. The alloys are melted in a quick fire and not exposed to contact with the flames any more than necessary. Moulds should be prepared in advance to ensure taking the metal from the furnace as soon as the proper temperature is reached, as the metal should not be allowed to remain in the furnace too long after reaching the pouring temperature.

The crucibles used are of graphite or a clay-graphite mixture. Excessive stirring or puddling during the melting is to be avoided, as this is not necessary; it tends to disturb the protecting cover and may cause contamination of the metal by furnace gases.

Charging

In ordinary practice, the charge will consist of about 50 per cent. new ingot and 50 per cent. remelt in the form of gates, risers, etc. With the correct melting conditions and the use of some ingot with each charge, it is not necessary to replenish the constituents of the alloys by additions of alloying elements. The ingot metal is charged first, together with enough glass for the cover and after this is melted down the scrap is added. Foundry scrap should be reasonably free from dirt and moulding sand. Care is taken that scrap is not allowed to be exposed to the furnace flame and then permitted to melt and trickle down through harmful gases. Such a procedure will cause absorption of reducing gases if these be present or, on the other hand, excessive oxidation and loss of metal if an oxidising atmosphere exists.

Machine-shop scrap in the form of turnings, borings, shavings, etc., can be successfully used in the charge. This type of scrap, however, should be kept dry and, preferably, free from oil or similar cutting compounds. Because of the high ratio of surface to volume in such scrap, oxidation and gas absorption must be kept at a minimum by melting down the material at a low temperature in a bath of molten metal. Contamination of the charge by other foundry alloys is to be rigorously avoided by maintaining a close control over scrap handling and setting aside the required melting equipment, such as crucibles or furnaces for such alloys.

Moulding

The copper-silicon alloys are very fluid and searching types of metal which makes it possible to run small castings of thin sections producing sharp and well defined outlines. The moulding in general would follow quite closely the practice for gun metal.

Sand Practice.—For these alloys, a fairly open sand will give the best results. The wide variety of castings for which the alloys have been used makes it rather impractical to suggest any one sand for all purposes. The moisture content should not exceed 5 or 6 per cent. For the best results, particularly on heavier sectioned castings, baked moulds are used.

Cores.—Cores should be made from an open, sharp sand with, preferably, linseed oil for a binder. The ratio of sand to oil is about 60 or 70 of sand to 1 of oil, and should be high enough to give an open and fairly soft core. Baking should be at 178 to 260 deg. C. for at least several hours and the cores may then be given a wash.

Ramming.—The moulds should not be hard-rammed close to the pattern but in the body of the mould away from the pattern the ramming can be somewhat harder. The permeability of the sand is improved by light ramming; it is also desirable that every chance be given the sand to contract in order to counteract hot-shortness during freezing and so lessen the danger of shrinkage cracks. There should also be vents to aid the escape of gases.

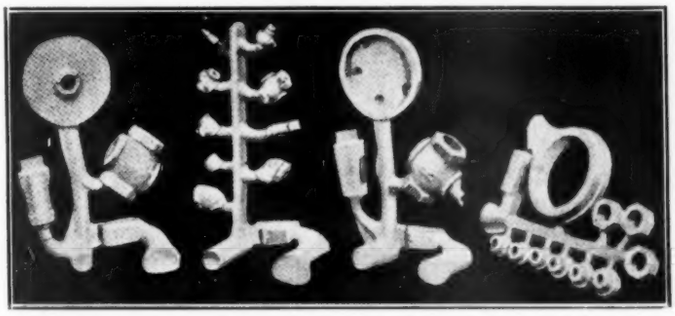


FIG. 1.—METHOD OF GATING SMALL CASTINGS WITH STRAINERS AND LARGE RUNNERS.

Gating.—Although there are a number of fundamental principles to be observed in gating, probably the most important is that every pattern is a problem in itself and should be treated as such. In general, the metal should enter the mould cavity near the bottom and with the least amount of splashing and turbulence. Gates are preferably placed at the heavier sections where it is possible to use feeding risers which will contain the hottest metal when pouring has been completed.

Strainer Gates.—For some castings, a good method is to pour through a strainer gate that can be choked quickly. The runner leading from the strainer should be cut considerably larger than the combined area of the holes in the strainer in order to reduce the pressure between the strainer and the casting. Fig. 1 illustrates the application of strainer gates for small castings. It will be noted that runners are made quite large and therefore act as feeders during freezing.

By-Pass Gating.—Some foundrymen prefer to use a by-pass and runner for pouring the copper-silicon alloys. The by-pass is placed in the drag of the mould and is cut deeper than the runner. The runner may be placed entirely in the cope

* This Paper was presented at a session on non-ferrous practice at the 1936 Convention of American Foundrymen's Association in Detroit, Mich. The authors are superintendent service engineering and assistant metallurgist respectively, the American Brass Company, Waterbury, Conn.

† Smith, C. S., "The Constitution of the Copper-Silicon System," Trans. A.I.M.E., Institute of Metals Div. (1929), p. 414, and "Alpha-Phase Boundary of the Ternary System Copper-Silicon-Manganese," Trans. A.I.M.E., Institute of Metals Div. (1930), p. 164.

or at the parting of the mould, half in the drag and half in the cope. The by-pass checks the velocity of the metal, and being cut deep, acts as a strainer, ensuring clean metal entering the runner. Branch runners from the main runner to the patterns are cut either at right angles or staggered back. This acts as a further check to the velocity of the metal and assures its flowing into the mould with the least possible disturbance.

Shrinkage.—The copper-silicon alloys have a moderately high shrinkage and have a freezing range that causes shrinkage of the interdendritic type. This results from the first metal to freeze sending out fingers or dendrites of high melting point constituent, and around these dendrites the last metal to freeze leaves voids unless precautions are taken to feed the heavier sections with sufficient molten metal.

Freezing should take place progressively from the thinner sections toward the heavier sections, which in turn should be fed with risers located as close to the section to be fed as is practicable. Feeding risers, if possible, should be located near the gates so that they may get the benefit of hot and fluid metal which has not been chilled in passing through the mould cavity. Risers should be of sufficiently large cross section so that the riser is the last metal to freeze. The height of the riser is not so important; in fact, blind risers extending only partly up through the cope are frequently used to advantage provided they are of correct cross section.

For securing sound castings, particularly fittings which must be leak-proof, it is also well to make use of as much hydrostatic pressure of molten metal as possible by pouring rather hot and having high sprues either through the use of high copes, built-up sprues or pouring basins. It is also quite important that generous fillets be used where the gates join the casting and where thin sections join heavier sections.

Inasmuch as copper-silicon alloys, when cast under proper conditions, have a good surface, it is urged only a small machining allowance be made wherever possible, in order to take advantage, as is the case with all castings, of the hardest and soundest metal on the surface or skin. In large castings where there is a long cooling period or in castings where it is impractical to feed all heavier sectioned bosses and lugs, chills are of benefit, particularly for castings subjected to pressure. The use of chills will help to secure progressive and uniform freezing toward the parts being fed.

Pouring

The alloys should not be poured at a higher temperature than is necessary for the metal to run satisfactorily. Castings poured at too high a temperature are susceptible to several types of defects. The alloy of 95 per cent. copper, 4 per cent. silicon, 1 per cent. manganese begins to freeze at approximately 1,000 deg. C. Large, heavy castings of this alloy are poured at about 1,067 to 1,120 deg. C., and small, light-sectioned castings are often advantageously poured as high as 1,232 deg. C.

The metal should be poured as slowly as is consistent with the running of the castings being made, especially in the case of large castings. The slower the pouring, the less liability there will be of scruff. For large castings, it is advisable to use a pouring basin. Glass used as a cover during melting is preferably skimmed off before pouring. This is best done by thickening the glass with a handful of silica sand before trying to remove it with a skimmer bar.

Cleaning and Finishing

Castings are sometimes sand-blasted before and sometimes after the removal of sprues, gates, and risers. Sprue cutters and band saws are used in trimming small castings. Hack saws, manually operated or power driven, and pneumatic chisels are used for larger castings. The castings may also be wire-brushed, pickled, or water-tumbled. Considerable expense can often be saved by a study of the most suitable saws and other equipment used in cleaning.

Machining.—The copper-silicon alloys are readily machinable where the correct procedure is followed, and a good lubricant is used. Where a refrigerant-base oil is employed, the work must not be allowed to stand any longer than necessary after machining in order to avoid staining. Tools should be high-speed steel with cutting angle similar to that used on brass except that turning tools should have slight top slope. Carboloy and chromium plated tools have also been used to advantage. The alloys can be machined at a speed equal to or higher than many alloys of less strength and inferior physical properties.

Welding

The copper-silicon-manganese alloy is readily welded with rods or electrodes of copper-silicon-manganese alloy of oxy-acetylene and electric arc methods. This makes it possible to join the castings, by means of welding, to other fabricated parts. The welding properties have been used to advantage by foundrymen in salvaging what would otherwise have resulted in defective or rejected castings. Blowholes, resulting from improperly vented cores or moulds, or scabs, occurring in the castings, can frequently be chiselled or bored out, and then filled up by welding with rod or electrode. After machining, the salvaged casting will be as sound as if the defect had not occurred and the weld will have the same strength as the cast metal.

Heat-Treatment

The copper-silicon-manganese alloy may be heat-treated (annealed) at temperatures of approximately 705 to 732 deg. C. and quenched to further toughen the metal, improve its machining qualities, remove casting strains from certain types of castings and increase the resistance to pressure.

Properties and Uses

Properties.—The copper-silicon alloys are strong, tough, corrosion-resistant alloys having physical properties superior to the tin bronzes and possessing the fundamental corrosion resistance of pure copper. The alloy of 95 per cent. copper, 4 per cent silicon, 1 per cent. manganese has approximate physical properties as given in Table I.

TABLE I.—*Approximate Properties of Copper-Silicon Alloy.*

Melting point, deg. C.	1,000
Specific gravity	8.15
Weight (lbs. per cub. in.)	0.294
Pattern-maker's shrinkage (in. per ft.)	$\frac{5}{16}$
Thermal conductivity at 20 deg. C. (cal. per sq. cm. per cm. per sec. per deg. C.)	0.06
Electrical conductivity at 20 deg. C. (per cent. I.A.C.S.)	4.9
Brinell hardness No. (10-mm. ball, 500-kg. load)	80
Tensile strength (tons per sq. in.)	22
Yield point (tons per sq. in.) (at 0.75 per cent. extension under stress)	8
Elongation (per cent. in 2 in.)	20
Reduction in area (per cent.)	25
Modulus of elasticity in tension (tons per sq. in.)	6,700

Fields of Use.—The copper-silicon alloys are non-rusting and offer excellent resistance to corrosion by a large number of normally corrosive solutions and compounds. However, similar to copper and all copper-base alloys, they are not equally resistant to all corroding agents or to the same corroding agent under all conditions. Corrosion may be particularly affected by the presence of oxidising agents. These alloys have been found of special value for resistance to atmospheric corrosion of all types in both industrial and marine locations and are also very resistant to corrosion by sea water as well as corrosive industrial and natural waters, to sulphuric and hydrochloric acid and many of their salts, to alkalis and many of the alkali salts. Good resistance is shown to certain organic compounds including alcohol, phenol, cresol, sugar solutions, fatty acids and organic salts.

The strength and toughness of the copper-silicon alloys are used to good advantage in castings of the bracket type. Many castings requiring such qualities coupled with good corrosion resistance have been used in sewage disposal equipment, marine hardware, chemical process equipment and other locations. A wide variety of such valves as a 16-in. gate valve weighing 18 cwts. made of copper-silicon alloy have found extensive use in highly corrosive atmospheres and liquids.

For making such a piece of equipment as a copper-silicon alloy kettle used for industrial plants where a durable and corrosion-resistant metal is required, good casting properties are essential. A water-wheel cast from a copper-silicon alloy, is another example of a casting requiring a metal which is cast readily and has good strength and corrosion resistance. Some of the other applications include drain fittings, electrical conduit fittings, and transmission line connectors. The fluidity of the alloys has been used to good advantage in casting intricate centrifugal pumps. The copper-silicon alloys may be expected to find greater use as the study and knowledge of their properties and service records become more widespread.

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(*Concluded from page* 390.)

5 per cent. elongation was reached. The strength was 0.65 ton per sq. in. for the lower nickel steels and 1 ton per sq. in. for the others.

The nickel-chromium steels *OWU* and *OWW*, for which no temperatures were recorded resembled the nickel steels *OWQ* and *OWS*, in developing 5 per cent. elongation with the low stress of 0.65 ton per sq. in. The 3.45 per cent. nickel steel (*OWR*) with 0.42 per cent. of carbon fell to the exceptionally low temperature of 1,245 deg. C. with a stress over 1 ton per sq. in. before registering 5 per cent. elongation.

Most of the high-alloy steels tested failed to acquire an elongation of 5 per cent. at fracture in the final test. With the castings of 12 per cent. manganese and 14 and 30 per cent. chromium steels the tests ended prematurely with low stresses, but with the tungsten steels the elongation was not produced with the maximum stress available. The 18 per cent. chromium steels with 2 and 8 per cent. of nickel reached temperatures of 1,255 deg. and 1,230 deg. C., respectively, with a stress above 1 ton per sq. in. when 5 per cent. elongation was recorded.

The tests on the 1 per cent. copper and 0.07 per cent. phosphorus steels also ended prematurely, but the temperature had fallen to 1,240 deg. C. with an elongation of less than 5 per cent. and a stress of about 1 ton per sq. in.

An increased rate of strain applied to a 0.3 per cent. carbon steel was found to raise the temperature at which elongation became apparent. Each five-fold increase in the rate (approximately 0.04 to 0.2 and 0.2 to 1 in. per min.) raised this temperature about 20 deg. C.

The author desires to record his great appreciation of the facilities provided by Mr. A. T. Black at the Royal Ordnance Factory Iron and Steel Foundry, where the early experiments were conducted, and to thank Mr. J. P. Harwood for his valuable assistance both in connection with these experiments and subsequently in the preparation of moulds.

Record Furnace Run

When the "B" furnace of the Bethlehem Steel Company, Sparrows Point, Md., was blown out on July 23, 1936, after seven years, four months, and twelve days of operation, it is believed a world's record for pig-iron tonnage was established, with 2,009,057 tons produced. During this run the brick lining required no repairs whatsoever. The furnace, which was blown in March 11, 1929, is now down for relining.

Melting of Cast Iron in the Foundry*

By S. E. DAWSON, F.I.C., A.M.C.Tech. (The Stanton Ironworks Company, Limited)

The melting of cast iron in the foundry has been the subject of so much thought and discussion in recent years that it is more in the nature of a review to date that one now approaches it. It is, however, of some value to consider the different melting furnaces available and compare the salient points in each case, with special reference to the principles involved, the raw materials used, the cost of operation, and the resultant metal.

Such a review would of necessity include the cupola, the rotary furnace, the crucible and the electric furnace, though attention will be mainly directed to the first two types. Since the raw materials to make up the iron charge are, to some extent, independent of the type of furnace, the main factors to be considered are the type of fuel employed, the rate and frequency of output, together with the efficiency and maintenance of the furnace and the quality of the metal produced.

It is useful in the first instance to examine the cost of melting in each case, apart from any merits which may be attributed to a particular type of furnace, and whilst it is difficult to give exact comparisons owing to each type being generally of different capacities and melting rates, the following may be taken as approximate figures for such sizes as are in common use.

Cupola	10s. to 15s. per ton.
Crucible	55s. to 90s. ,,
Rotary coal-fired	14s. to 16s. ,,
Rotary oil-fired	20s. to 25s. ,,
Electric furnace	50s. to 60s. ,,

Other factors to be considered are generally concerned with the raw materials to be used and the quality of metal required, whether for high-duty purposes or of special alloy composition for specific purposes.

The Cupola

Generally speaking, the cupola is still the main melting unit in the foundry, and the application of other types of furnaces for cast iron has been largely brought about by recent advancements in the metallurgy of this alloy. The cupola, however, is limited in its use of raw material which, on account of the intimate contact with the air and gases, is mainly confined to the heavier forms of iron, such as pig-iron, cast iron and steel scrap, whereas the open-hearth type of furnace is capable of dealing with lighter and cheaper materials, such as cast-iron borings and steel turnings, which offset to some extent the greater cost of melting.

The greater and more prolonged concentration of heat in these furnaces gives higher metal temperatures with refinement of structure, and permits the use of large amounts of ferro-alloys if required, and the choice of wider analysis in the raw materials without risk of irregular final composition.

The cupola has retained its original form of construction, though some modifications as pre-heating the air supply with the waste gases as in the Griffin hot-blast type, supplying secondary air to promote more complete combustion as in the Poumay system, or controlling the primary air by adjustable valves to ensure more regular combustion, as in the Balanced-Blast cupola, have met with considerable success where adopted. The theoretical operation of the cupola is too well known to warrant discussion here, although in practice certain fundamental rules must be observed to obtain maximum efficiency from the fuel employed. This can only be attained by ensuring complete combustion of the coke or its products, and the special cupolas referred to are designed to achieve this object or to make use of unburnt gases.

For complete combustion at least sufficient air must be supplied to burn the carbon in the coke; the amount of the latter in the ratio of 10 to 1 is dependent on the capacity of the cupola selected to meet the requirements of the foundry, which will be about 11 to 14 lbs. of metal per sq. ft. of diameter at tuyere level. Theoretically, 1 lb. of coke (90 per cent. carbon) requires 10½ lbs. of air or about 140 cub. ft. for complete combustion, but in cupola practice it is found that an excess of 10 to 20 per cent. is necessary to achieve this object. Fig. 1 shows the effect of reducing the air supplied to a cupola melting iron for repetition work. The improved results obtained as the air was reduced to about 165 cub. ft. per lb. of coke is at once apparent.

The heat produced from 1 lb. of coke would melt and superheat considerably more than ten

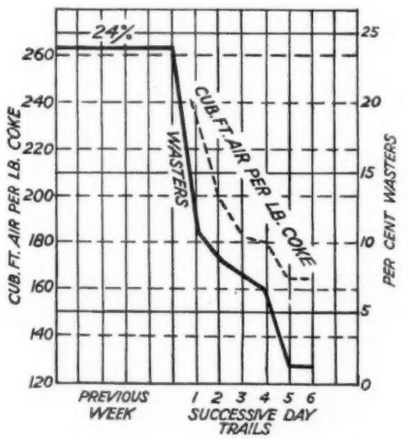

FIG. 1.—INFLUENCE OF VOLUME OF AIR SUPPLIED TO CUPOLA UPON PRODUCTION OF WASTER CASTINGS.

times its weight of iron, in addition to raising the temperature of the slag, furnace walls, etc., and iron to coke ratios of 18 to 1 have been obtained with excessive air at increased pressure. Such conditions, however, bring about serious oxidation of the iron, increase the overall losses, as well as silicon and manganese, and produce a metal of increased shrinkage.

More efficient production and utilisation of the heat available from the coke is obtained in the Balanced-Blast cupola, the design of which is now familiar to most foundrymen. In this type the object is to control the distribution of the air better and to provide a reducing atmosphere in the lower portions of the coke bed through which the molten metal passes and where superheating takes place. Both objects are accomplished by supplying sufficient air of relatively soft blast into the coke bed to provide carbon monoxide (CO) whilst the remainder of the air is projected in at higher levels to burn the carbon monoxide to carbon dioxide (CO_2).

The lower air is admitted through large valved tuyeres (Fig. 2), whilst a graded size of small auxiliary tuyeres of predetermined area and in successive rows, usually three, gives progressive combustion of the CO to CO_2 and a gradual increase in temperature to the top of the coke bed.

A higher pressure maintained in the wind belt secures better penetration of air from the auxiliary tuyeres across the section, giving a more uniform gas atmosphere and temperature at the melting zone.

Such uniformity in gas composition minimises the oxidation of the metal, which in the ordinary cupola mainly takes place in the outer annulus where the gases are strongly oxidising and the heat is greatest.

The greater efficiency of combustion in the Balanced-Blast cupola is shown in the following gas analyses (by volume) of the top gases taken over several hours run by Mr. J. E. Fletcher, the designer of the furnace, in two cupolas similar in every respect except that one was fitted with the special wind belt and tuyeres.

	Normal cupola. Per cent.	Balanced-blast cupola. Per cent.	Complete combustion. Per cent.
Carbon dioxide ..	12.8	18.5	20.7
Carbon monoxide ..	8.9	1.4	0.0
Oxygen	0.4	0.6	0.0
Nitrogen	77.9	79.5	79.3

The efficiency of combustion and better distribution of the heat in the Balanced-Blast cupola was reflected in the coke consumption which was between 30 and 40 per cent. less than that in the original design of cupola.

Continuous tapping through a syphon block (see Figs. 3, 4 and 5) is a feature of many cupolas to-day and has several advantages to commend it, including hotter metal, less attention to tap hole and less wear on the cupola lining below the tuyeres and possibly less sulphur pick-up.

Crucible Furnace

Brief mention only will be made of the crucible furnace. Its value lies in the fact that the metal is not in direct contact with the fuel, so that special compositions and expensive alloy cast irons can be made with exactness, and comparative freedom from gas is obtained with obvious advantages. The cost of melting cast iron in the crucible furnace is considerably higher than for other types of furnace, coke, for example, melting little more than its own weight of iron and the upkeep in crucibles being also a contributory factor.

Certain modifications of the structure of cast iron may be brought about by the order of adding the raw materials, for example, steel will refine the graphite, whilst ferro-alloys will coarsen the graphite if such additions are made at the end of the melt. The first heat may take as long as 3 hours, though later heats may be reduced to about 1½ hours, depending on the character of the charge. The melting costs, exclusive of the metal, may vary from 55s. to 90s. per ton, according to the size of furnace and other considerations.

Rotary Furnaces*

The design and construction of the different types of rotary melting furnaces now in use are somewhat similar, any variations being in respect of the manner or means adopted to burn the fuel, and the utilisation of the waste heat for the purpose of raising the temperature of the air of combustion in order more efficiently and rapidly to burn the fuel. The furnace body, the overall length of which is generally about 2½ to 3 times the diameter of the shell, is tapered at both ends and the metal bath is situated in the centre. Two tapping holes are usually provided, one in either side of the furnace body, to obtain more even wear on the lining by their alternate use.

The main factors to be observed in the design of such a furnace are the rate of input of heat in relation to the size of metal bath, and the mass of refractory lining material in which to collect such heat for transference to the metal. In a suitably designed furnace the amount of

* Extracted from a Paper read before the Wales and Monmouth Branch of the Institute of British Foundrymen, Mr. Southcott presiding.

* For fuller details see Paper "Rotary Melting Furnace Practice," by the author, FOUNDRY TRADE JOURNAL, February 28, 1935.

fuel required for a given weight of metal follows the standard requirements of raising the cold charge to melting point and superheating the molten metal to the desirable degree. The efficiency of the absorption of heat by the refractory lining and by the air of combustion passing through the preheating system is important in considering the heat balance of the furnace. It is found in practice that a suitable mass of refractory for heat transference is obtained by a lining thickness of about 2 in. for each foot of shell diameter.

For supplying a multiplicity of small castings the intermittent operation might be a disadvantage unless the casting arrangements were so organised to take supplies from a ladle or receiver into which the whole bath had been tapped, so that the furnace can be recharged without delay. As the size of castings increases, however, this problem becomes less difficult, since the number of moulds ready at one time are less, and an intermittent supply is often more convenient. The rotary furnace is made in sizes of 1, 2, 3½, 5, 10 and 15 tons capacity, and a close study of the size and rate of production of moulds must be made before the size of melting unit or units is decided upon.

When exact precision in analysis is required, as, for example, in chill rolls, steels, wear-resisting castings, and alloy irons, the metal can be held in the furnace whilst being sampled and analysed prior to making final adjustments in composition which may be found necessary. The character of burner employed depends on the type of fuel used, and in each case these have been developed to a high degree of efficiency by the various furnace makers concerned.

Where a battery of furnaces is in operation, a central mill delivers the coal supply to the hoppers in rotation, or as required. The air preheater or recuperator, situated in the exhaust flue, is generally of the tubular type, the tubes

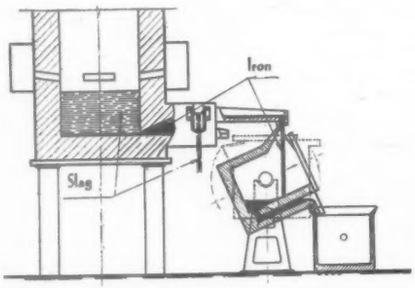

Fig. 3.—Diagram showing Arrangement for Continuous Tapping through Syphon Block.

coal is used, but where complete combustion relies on a source of secondary air entering round the burner as in the open type, the coal may be of a bituminous soft quality.

The speed and efficiency with which powdered coal will burn depends mainly on the size of the particles, the temperature of the mixture of air and coal, and the percentage of volatile constituents present.

For a given size of particle the other two factors are dependent on each other, and for immediate ignition as required in the rotary furnace the following figures show the relative temperatures for a range of pulverised coals normally available:—7 per cent. volatile in the coal requires a temperature of 550 deg. C.; 10 per cent., 460 deg. C.; 13 per cent., 400 deg. C.; 15 per cent., 330 deg. C., and 18 per cent., 260 deg. C. Bituminous or soft coals containing 30 per cent. or more of volatile constituents will, of course, burn at once with cold air. In a rotary furnace, therefore, where the heat in the waste gases is not utilised, only soft coals can be used.

These temperatures are within the range of those obtainable from the waste gases, and relate to coals which have been so pulverised that 75 to 85 per cent. will pass through a 200 mesh, a degree of fineness imposed by the practical limitations of economic production. Beyond this degree of fineness the above temperatures of the volatile contents could be reduced and still give immediate ignition.

When once the dampers are set, the position of the flame relative to the burner or grid tends to adjust itself to the position as set. A flame burning too far along the furnace produces a high flue temperature, which raises the air temperature and therefore the speed of ignition, and automatically withdraws the flame again to the burner or grid.

The close control and intimate admixture of both the air and fuel supplies allow a near approach to theoretical combustion, so that a minimum oxidising atmosphere can be maintained in the furnace. The amount of air required to burn both the carbon and volatile matter in average suitable coal is 135 to 140 cub. ft., or about 10½ lbs. by weight, and any excess over this absorbs heat from the flame and should be avoided.

The selection of a suitable lining for the rotary furnace has been the subject of much thought and experiment. The conditions are more severe in this type of furnace than in the cupola, not only on account of the higher temperature attained, but also due to the more direct abrasive action of the charge, and of the fuel and air stream entering the furnace, and direct contact between the molten metal and the refractory. Whether bricks or a rammed monolithic lining be used, much care has to be exercised in their application, and since thermal expansion occurs in all siliceous refractory materials, suitable provision must be made to allow this to take place, both gradually to avoid spalling, and

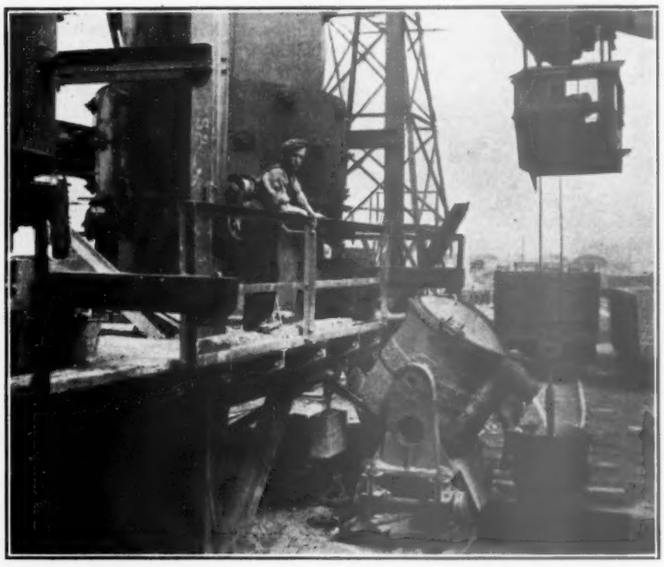

Fig. 2.—Balanced-Blast Cupola with Receiver in Foreground.

Fig. 4.—Close-up View of Arrangement for Running-off Slag during Continuous Pouring.

themselves being made of specially treated steel to withstand the temperature of waste gases in the flue. Appropriate gauges for recording the air temperatures and pressures are installed to allow constancy of operation and efficient working of the furnace.

The rotary furnace may be fired with either oil, pulverised coal, or gas. Where oil is used, this is of the fuel-oil type, with a specific gravity of about 0.92. To maintain a constant pressure to the burner the oil is supplied from an elevated service tank fed from the main storage tank. The fuel consumption is generally about 15 to

within the mass of lining itself to avoid damage to the shell of the furnace.

In monolithic linings, internal expansion can be largely provided for by a suitable density of material, as controlled by the degree of ramming and the moisture content.

Preparation of Linings

Many ganisters have been recommended for use in the rotary furnace with varying success, and whilst an ultimate composition of about 88 per cent. silica, 8 per cent. alumina and 1 per cent. oxides, with loss on ignition as balance,

seems to be the desirable basis, the number of heats given by such a material is influenced by the physical characteristics, such as grain size and the type or nature of the clay present.

Although many data are still lacking to establish the more exact effect of grain size in this connection, it is probable that the best results would be obtained with material approximating to the following sieve test:—

	Per cent.
Retained on 30 mesh	20–25
,, 60 ,, ...	40–45
,, 90 ,, ...	15–10
,, 120 ,, ...	5–10
Passing through 120 mesh	20–10

A suitable density to avoid undue internal disturbance during fritting and in service is about 2.3. A suitable moisture content is 6 to 8 per cent., preferably added on site to the dry material as received by sprinkling water through a rose on to successive inch layers until the desired quantity of refractory is laid down. After leaving to mature for three or four days, suitably covered to avoid evaporation, the mass is cut sectionally and relaid in a similar manner, water being sprinkled on between each 2 in. layer. Further maturing for a few days should be allowed before use, when almost maximum strength will be attained.

Experience is necessary to ram to the desired density, and it is generally advisable to feed the material under the rammer somewhat lighter near the shell of the furnace to allow expansion to be taken up and to facilitate the passage of steam to vent holes provided in the shell.

The internal shape and size of the lining is controlled by sectional formers suitably bolted where necessary to permit of removal in parts after use. After air drying, the lining is dried by hot air or coke, an operation to be extended over several days or longer if possible. To avoid undue haste in these operations, the provision of a spare or duplicate furnace body is essential. Initial fritting of the lining prior to use for melting should be as slow as possible in order to avoid spalling and possible internal disruption. Such precaution is specially important up to about 500 deg. C., when the main expansion has taken place.

The general wear of a lining in service can to some extent be counteracted by repeated additions, between heats, of siliceous material or powdered recovered refractory, preferably in intimate admixture with small coal. Where more localised holes or depressions are concerned, patching with new material is necessary after chipping-out to ensure good contact and substantial thickness, well keyed at the outer edges of the patch.

By careful attention to the foregoing points, it is possible to obtain as many as 300 heats from an individual lining when melting grey iron, although owing to the many factors involved, an average of 200 to 250 may be considered good practice.

Where higher temperatures are concerned, as in melting of malleable cast iron, this number is somewhat reduced and where steel only is melted may fall as low as 50. Up to the present, acid linings only have been used in practice, although some attention has been given to the possible use of a basic lining, suitably insulated from the shell to overcome the greater heat conductivity.

Exclusive of the first heat from a cold furnace, metal may be tapped in about 2¼ hours after charging, varying from 2¾ hours for malleable tapping at 1,500 deg. C. and 2 hours for grey iron at 1,450 deg. C. Low-carbon irons and steels may take rather longer, and oil firing tends to reduce these times. To the first heat an additional time of about 1 hour must be added for heating up the lining and flues.

The absence of internal reactions in rotary furnace metal and greater freedom from slag inclusions contribute to preserve the greater fluidity and refinement of structure, a feature of cast iron which allows of wider range of composition to meet required physical properties, with distinct advantages in foundries making many types of castings.

The amount of FeO in the slag is usually below 2 per cent. and this limits the reactions taking place between the slag and such oxidisable elements in the bath, as silicon, manganese, so that such losses are lower than when a higher oxidising slag is present.

As in other types of furnaces, however, such oxidation as may occur during the melting-down process varies somewhat with the nature of the materials charged, but the losses are in general less than those experienced in the cupola, whilst the carbon is controlled with reasonable precision.

Costs

Where more than one furnace is operated, some of the labour is spread over a larger tonnage; also, special considerations may control

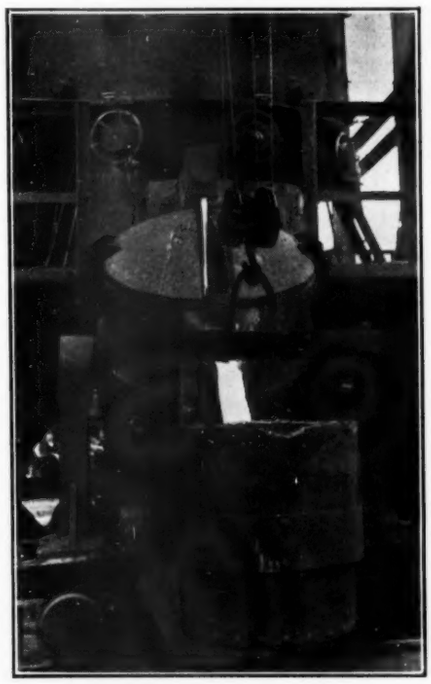

FIG. 5.—TAPPING THROUGH SYPHON BLOCK INTO THE RECEIVER AND THENCE INTO THE LADLE.

the cost of fuel employed, whilst supplies of raw materials available, type of castings made, and different methods of computing costs also influence the figure.

Assuming a single unit in each case and stating the costs on the basis of a ton of molten grey cast iron at the spout, the following figures, exclusive of overhead charges, may be considered as representing average melting practice:—

	s.	d.
Refractory lining at 80s. per ton and 200 heats	2	0
Labour	2	9
Power at 0.75d. per unit	1	0
Maintenance	1	0
Limestone and sundries	0	3
Interest and depreciation	4	0
	11	0

To this must be added the cost of fuel in each case. These are calculated on the appropriate rates per ton and ratios of fuel to metal melted as follows:—

	s.	d.
Bituminous coal (pulverised), at 20s. per ton and 18 per cent. ratio	3	7
Anthracite coal (pulverised), at 24s. per ton and 18 per cent. ratio	4	4
Fuel-oil at 80s. per ton and 15 per cent. ratio	12	0

The total costs are therefore:—

Pulverised coal (average 4s.) .. 15s. per ton of metal melted.
Oil .. .. .. 23s. ,, ,, ,,

It will be understood that in general the melting costs will be somewhat heavier for the smaller furnaces and lighter for the larger units, but such differences may be offset by the conditions prevailing at each furnace, depending on the tonnage output obtained, that is, the number of heats made per day continuously.

The above average costs assume an output of three heats per day or 15 per week, although four heats per day could be readily maintained. Since these costs do not include the metal, it should be realised that considerable reduction in cost may be shown in cases where cheaper forms of raw material are available.

Metallurgical Considerations*

Reference has already been made throughout these considerations to the importance of contact between the gases prevailing in the furnace and the molten iron, and it will be evident that the cupola is not so well placed as the open-hearth type in this respect, since all the metal has to pass through the rising gases and the coke bed prior to collection in the well.

As already seen, the Balanced-Blast cupola is specially designed to avoid as far as possible contact of the globules of liquid metal, with oxidising gases, which include carbon dioxide ($Fe + CO_2 \rightarrow FeO + CO$) as well as oxygen, thus avoiding not only loss of iron, etc., but also the formation of scouring slags detrimental to the lining.

The possible importance of gas absorption and certain non-metallic inclusions on the graphite size and properties of grey cast iron is considered in the recent work of A. L. Norbury and E. Morgan (Iron and Steel Institute, September, 1936), who suggest that the presence of solid inclusions promotes large graphite growth, whilst supercooling occurs, forming fine graphite if the inclusions are liquid. The nature of the gases with which the molten metal may be in contact, that is, whether oxidising or reducing, may react on the non-metallic inclusions in the latter case to raise the freezing point and thus promote graphite growth. Of more immediate practical interest, perhaps, is the persistence after re-melting of some properties of the raw materials employed in the charge.

In conclusion, the author wishes to thank the Stanton Ironworks Company, Limited, for their courtesy and interest, and also Sir W. G. Armstrong Whitworth & Company (Ironfounders), Limited, and the British Cast Iron Research Association for the use of the slides exhibited.

DISCUSSION

MR. S. SOUTHCOTT (President), in opening the discussion, said that he believed that the cupola having auxiliary tuyeres in spiral form was originally designed by a Welshman named Grange, who, through lack of capital, was unable to develop his ideas. He thought that a cupola which was in use at the works at which he was employed was one of the original type as made by Grange. This idea had lain dormant for some time, but it was re-established and had been extensively exploited.

Volume Control

MR. C. E. WILLIAMS said he would be glad if Mr. Dawson would tell the members how to arrive at the correct volume of air. The pressure when using a fan might be known, but he was not always aware of the volume supplied to the cupola. Mr. Williams said that when attending the Newcastle Convention he had visited the Close Works where he saw the rotary furnace in action, and it was astounding to observe the type of metal one could charge and still produce undoubtedly high quality metal.

MR. DAWSON, in reply to Mr. Williams, said he considered 220 cub. ft. of air per lb. of coke gave good clean castings, and he thought the Poumay cupola could be worked to give good results. With regard to volume, by using a

* This phase was dealt with more fully by the author in a Paper printed in the FOUNDRY TRADE JOURNAL, November 7, 1935.

Roots blower it was very easy to calculate the volume by taking the internal volume of the blower and multiplying it by the revolutions of the blades. Volumes from fans were not so easy to calculate, but there were very reliable meters in use which would indicate the volume as well as pressure. Pressure was not so important, but in order to get the best results from the coke charges, volume control was essential. Mr. Dawson agreed that a syphon tapping spout, although somewhat novel at present, was becoming more popular and was now used in the best foundries.

In giving a comparison between the cupola and rotary furnace, it took one hour to heat a medium-sized furnace and two hours to melt the charge, after which repeat charges could be obtained quite regularly and the furnace could be run for 24-hour periods.

Fans and Blowers

In reply to MR. R. G. WILLIAMS who asked whether a fan was preferable to a blower, MR. DAWSON said he preferred a fan because of its automatic adjustment. With a blower one had a positive pressure and if for any unexpected reason a choke occurred in the tuyeres or piping, or the tuyeres became blocked with slag, the blower might not drive its pressure through and then something of a very serious nature might happen, but with a fan, if there should be resistance to the supply of air, there would not be such a serious effect. In reply to MR. J. P. GALLETLY who asked if the fan could be varied in speed to suit the requirements of the cupola, MR. DAWSON said there were some fans made with switchgear which could be regulated to give any speed required.

Pulverising Costs

MR. R. J. RICHARDSON reminded the lecturer that he had mentioned a figure of 50s. to 60s. per ton for the cost of electric furnaces. In working out his costs for fuel-fired furnaces, had he taken into account the cost of pulverising, and could be give any idea of what that would amount to?

MR. DAWSON replied that the cost of pulverising would be about 7s. It did not vary more than a few pence per ton, and this was included in the estimate given.

MR. M. WAYMAN asked whether one or two rows of tuyeres were preferable.

MR. DAWSON replied that two rows of tuyeres naturally increased the area of melting, if they were not too far apart. They obviously gave a wider area for the distribution of the blast, and this had a beneficial effect on the oxidation of the fuel.

MR. W. S. SMYTH asked whether, when working with a Balanced-Blast cupola, one would operate with a larger bed of coke and a greater distribution of the blast. He suggested that there would be a greater danger of the iron absorbing carbon.

MR. DAWSON said this would depend upon the temperature, and the fact must not be overlooked that there was a limit to the amount of carbon pick-up. Iron could absorb carbon to a limited extent only. In answer to a further question, Mr. Dawson recommended that the coke bed should always be at least 2 ft. above the tuyeres.

The meeting concluded with a vote of thanks to the lecturer, proposed by MR. A. S. WALL, seconded by MR. W. S. KINSMAN, and carried with acclamation.

Heat Effect in Water

In the course of an article on "Heat Effect in Welding" in "The Iron Age," DR. W. G. THEISINGER outlines the method and conclusions of his own research into the variables which influence the welding of steel, with particular reference to the effect of welding heat on the parent metal adjacent to the weld. Speed of welding and the base metal composition are the main variables analysed. The article contains considerable data of practical interest to steel producers and welding fabricators.

Co-operation Between Foundry and Melting Shops*

BY J. PEARCE.

One of the most important sections of a foundry is the melting department, and close co-operation between it and the foundry is essential for the production of good castings. This Paper suggests lines along which this co-operation may be developed, particularly in those foundries in which the melting unit is not an integral part.

For effective co-operation, it is necessary that there be an exchange of information, and it is suggested that, in addition to the usual information regarding quantity and composition of the metal required, knowledge on the following points be imparted to the melting unit by the foundry, in respect to each cast:—

(1) Approximate weight of individual castings and number of runs in the cast. The heavier the casting, the cooler the metal usually required. The greater the number of runs in the cast, the longer the metal must remain liquid in the ladle. Both these points are, therefore, related to the casting temperature.

(2) Information regarding the life of the castings. By life is meant the ease with which

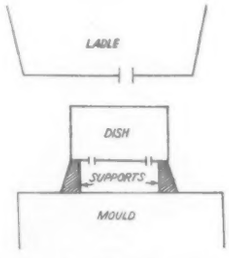

FIG. 1.—MOULD RUN WITH DISH RUNNER.

the metal can completely fill the mould. This is dependent on the size of runner, intricacy of section, and the number of cores in the mould to be circumvented. It is necessary for the fluidity of the metal to be such that this can be successfully accomplished.

(3) Whether the moulds be made in dry-sand or in green-sand seems, at first sight, to be superfluous to the melting department, but closer examination shows that this is not so. Metal loses temperature more rapidly in green-sand than in dry-sand, it tends to run more sluggishly, and this factor must be allowed for at the furnace. Again, certain types of steel (particularly the higher-carbon steels) are more liable to disturbance in green-sand than in dry-sand. If, at the furnace, the type of moulding sand be known, this tendency can be allowed for and counteracted. Also, through foundry co-operation, a cast may be composed wholly of dry-sand moulds, or wholly of green-sand, as opposed to a mixture of the two, and in this case a more suitable cast of metal could be given.

(4) Data relating to the rate of pouring. This calls for the closest co-operation between moulding and melting shops. It is particularly necessary when the stopper-type ladle is used, as co-relation between the pressure in the ladle, size of nozzle, and runner-size are essential. A particular case in point is the mould run with a dish runner, as shown in Fig. 1; the ideal is, of course, to maintain a good head of metal in the dish. Should the nozzle or dish runner sizes be incorrect, the result will be, either the sides of the mould will be splashed with metal, through running with too faint a stream, or the ladle nozzle will have to be retarded, with consequent danger of trouble with the stopper.

Furnace to Foundry

Information should also be given to the foundry by the melting unit—for instance, the probable running properties of metal of a different composition from that usually met with, particularly with the introduction of alloying elements. If chromium be introduced, the metal will run thicker, and realisation of this by the moulder will result in larger runners being made and a better provision for the running of the casting. It is also a practice, in certain high-speed production foundries, to strip the castings when still hot. Certain qualities of steel will not stand this treatment without cracking, and any knowledge of this nature, imparted to the foundry, will help to avoid wasters.

To be effective, all co-operation must be practical, and the following are some points where closer co-operation may result in increased efficiency.

It is bad practice to keep the furnace waiting, when a heat is ready; metal is not improved by "stewing." In the case of steel, it definitely loses certain running properties, and has a tendency to stiffen. To overcome this, a higher casting temperature is required, which results in the risk of damage being done to the mould; fusion of sand to the castings; a large crystalline structure, and risk of segregation. By working the moulding machines to a time schedule, and having the moulds ready well in advance, better castings are obtained.

If a number of moulds be poured from one ladle, there must be a fall in temperature gradient between the first and last mould poured. If the castings be dissimilar, they should naturally be arranged so that those requiring the highest pouring temperature are cast first. Where the castings are identical, then a safe pouring range will have to be found and adhered to. By the co-operation of foundry and melting shops, the moulds should be pitted as close together as possible, and as near the furnace as practicable. Time is thereby saved in disposing of the metal from the ladle, it can be cast at a slightly lower casting temperature, and the risk of a bad cast through ladle faults can, to some extent, be avoided. It is often a good plan, if space permits, to reserve an area for casting only, where the moulds can be pitted, cast, removed and the moulds for the next heat prepared; instead of carrying the metal up and down the foundry as is sometimes the case.

Great assistance can be given to the melting unit by the foundry in the effective control of scrap and feeder heads. With the growing use of alloy steels and irons, a larger tonnage of metal containing alloying elements is returned to the furnace. These present some very unpleasant problems to the maker of plain carbon steels for castings.

Waster Castings

When wasters occur, it is very easy for the foundry to blame the metal, and, conversely, for the melting shop to blame the moulds. Effective co-operation would eliminate this difference of opinion, and it is suggested that either an inquiry be made, or the defective castings submitted to an independent body, probably a research department, from whence, after a thorough investigation, suggestions could probably be made as to future procedure, should a replacement be necessary.

In conclusion, it is urged that the foundryman works in close co-operation with the melting department. The one, with his knowledge of the behaviour of metals, and the other, with his knowledge of the requirements to be fulfilled, can effect that co-operation which will ultimately result in a first-class product.

* An entry for a Short Paper Competition organised by the Sheffield Branch of the Institute of British Foundrymen.

Moulding Sand Control

Mr. V. Delport presided over the first part of a joint meeting of the London and Birmingham Branches of the Institute of British Foundrymen, held at the Charing Cross Hotel, London, on October 24. After a Paper, "Some Factors Influencing the Production of Sound Castings" (printed in our last issue) had been read and discussed, Mr. Delport invited Mr. G. W. Brown (President of the Birmingham Branch) to preside.

MR. BROWN accepted the invitation, and on behalf of the Birmingham members expressed appreciation of the privilege afforded them to take part in the meeting.

A Paper on "The Application of Science to the Control of Moulding Sands," by H. H. Shepherd, was then presented. This was printed in our October 29 issue.

MR. F. GENTLES asked what varieties of Erith sand the author had used, and particularly whether he had used the medium grade and what results he had obtained. It would be interesting if the facings trade would provide a coal dust which would not give silt.

MR. SHEPHERD replied that he had tried all the varieties of Erith sand but had not found any appreciable difference between them. He would not criticise Erith sand, because it was particularly useful for some purposes. Much depended upon the application of good foundry technique, venting, etc.

Minimum Coal Dust Addition Advocated

MR. H. WINTERTON (President of the Institute) said he agreed with the statements made in Mr. Shepherd's Paper concerning coal dust. He recalled a Paper which he had delivered at Birmingham, in 1908, in which he had stated: "Do not use too much coal dust; very carefully calculate the amount necessary. For large castings use a coarser coal dust than for the fine castings. It is essential to measure and add exactly the same amount each time." In the past, he continued, far too little attention had been paid to the mixtures; perhaps, also, far too little attention had been paid to the qualities that had been produced, but nowadays standard qualities were produced in a scientific manner; in some works, indeed, all raw materials were subjected to the most complete analysis every time that mixtures were made. Of course, the consumer must use them in his own particular way, but founders were realising that in the handling of raw and prepared sand more specific care was necessary than had been applied in the past. The Institute had been of great advantage not only to the founders but also to those who had to supply the needs of the founders, by leading them in the right direction. He hoped sincerely that the time was not far distant when some definite standard might be arranged between the various bodies, whereby founders would be able to obtain sands to their particular requirements, as well as other ingredients, so that materially fewer wasters would be produced.

MR. SHEPHERD said that the facings trade could, and did, supply materials to specification, and would be willing to co-operate with any who required specifications to suit their particular purposes. It was pleasing to note that so many years ago Mr. Winterton had warned the founders against the excessive use of coal dust.

The Silt Problem

MR. J. W. GARDOM (Past-President of the London Branch) asked if it were not possible that silt was produced, but was carried away; it was likely that at the knock-out, where there was bound to be air suction, that the silt would be removed. Some years ago he had advocated the installation of plant to eliminate silt, but nowadays he did not believe that it was necessary. He was convinced that a certain percentage of silt was essential to the making of a really good casting, for without it the contractions in the sand were such that a bad surface was produced on the casting. With regard to the air separation of the silt in mechanised foundries, he recalled the author's statement that if that separation were to be successful, the sand must be thoroughly dry, and the suggestion that a fan be used for withdrawal at the elevator. The best place for the fan, he suggested, was over the knock-out, because there the sand, with the silt in it, was hot and dry, and, further, one could improve the usually unhealthy working conditions at the knock-out.

He had recently become acquainted with a firm making driers and had persuaded them to carry out some experiments on sand drying. Regardless of the original moisture content of the sand, it could be reduced to any percentage desired. Unfortunately, this process cost a good deal of money, and he doubted whether foundries could afford the cost of it.

Controlled Moisture Content Dryers

If the contamination of moulding sand by core sand, or *vice versa*, were bad, it seemed worth while considering the installation of suitable plant for the separation of the two types of sand. The separation could be effected quite easily, provided a founder would spend the money, and he was convinced that the capital outlay could easily be recovered. If that were so, it did not seem advisable to mill all the sand used to facing quality, as the author had suggested was the case in a mechanised foundry. The best material to use for facing was a well-milled fine sand with good bond; the backing sand could be quite open, provided it would hold together. It seemed advisable to use a finer sand at the face, whatever the size of casting, and a coarser backing sand in order to secure permeability. The separation and recovery of sand in the various grain sizes used in the different parts of the mould was well worthy of very full investigation. The engineers of the Austin Motor Company had done much work in that direction, and perhaps Mr. G. W. Brown would be able to publish the figures, as they would be valuable to many foundries. The main difficulty in milling all the sand to facing quality was that of cost; in mechanised foundries using 100 tons of sand per hour, they could not afford to mill all the sand used. They were obliged, therefore, to separate the facing sand and backing sand qualities, and he did not think the time spent in making the moulds was appreciable, provided proper arrangements were made for the delivery of the two types of sand to suitable places.

In expressing the hope that Mr. Shepherd would conduct further work on sands, particularly from the point of view of the conditions in mechanised foundries, Mr. Gardom asked whether it would be possible to carry out bonding tests with various sands and mills, in order to ascertain what types of mill would produce a certain bond in a given time. The results of such tests would be of very great advantage, and he suggested that it would be best for a private firm to do this work. The rammed density of the various sands in the moulding machines was also important; questions such as whether a sand required 100, 80 or 60 bumps had an important influence on production in a mechanised foundry, and, of course, it was on the production that a mechanised foundry either paid or lost money.

Mr. Gardom agreed with the author that grain size was about the most important factor in sand testing; he did not think it was of any use mentioning the moisture content without giving also some indication of the grain size.

Knock-Out Considerations

MR. SHEPHERD replied that to some extent there was air separation of the silt in the plant that he used, although no fan was used. The plant relied entirely on natural draft, using extension pieces over the bucket elevator and the casting grid. He had never determined what silt was present immediately before the casting entered the knock-out, where the suction was applied, but he had taken samples of sand from the bottom of the bucket elevator and had found no appreciable amount of silt there. The gunmetal foundry was not yet operating on the mechanised basis, and during the last few years he had not found any appreciable increase of silt. If an excessive amount of coal dust were added, there would immediately be an increase in silt and decrease in permeability.

The suggestion to place a suction fan over the knock-out for the purpose of drawing off the silt was a good one, but as the fan would be operating over very hot and steamy sand it would be apt to draw off a quantity of the sand itself. That was why he had always relied on natural draft over the casting grid. Over the bucket elevator, however, there was a possibility of using a good suction.

The ability to dry sands to definite moisture contents was important. Speaking without knowledge of the drying plant to which Mr. Gardom had referred, he said it might be necessary to employ someone on the plant to control the moisture contents of the sands with which it dealt. Possibily the man who was handling the plant could do that.

Two-Sand Developments

It seemed that Mr. Gardom had misunderstood the views expressed in the Paper with regard to facing sand. He had stated in the Paper that there was, or should be, a movement away from making all the sand like facing sand. For example, things were done on such a high speed scale in America that the mass handling of sand became a vital factor, and obviously they had sought to eliminate the use of a separate facing sand. But latterly there had been a distinct movement towards the reintroduction of facing sand in American foundries, for they had found that it paid to use a separate sand for facing instead of preparing the whole of the moulding sand to facing sand quality.

The efficient milling of the sand was essential in any system if one were to obtain full value from the system. He could speak from experience in that matter particularly, because some trouble had been experienced in connection with a unit recently installed. The engineers concerned had said that the mill should go in one place, whereas the foundrymen and the metallurgists had said that it should go somewhere else. The engineers' opinion had been followed, and a serious amount of new sand had had to be used in that system in order to maintain the quality. Ultimately the mill had been moved to a position in which it could give efficient milling. The equipment makers should market an equipment which would mill sand efficiently in a continuous plant. An attempt had been made in the United States; but the problem of cost was important, and there were limits to the amounts which even the large companies could afford to spend on sand plant.

He had done some work in connection with bonding times, and would gladly undertake to carry out further tests, possibly by taking samples at various parts of the system and running them through the mill. By that means it might be possible to find some valuable information.

The rammed density of moulds was of vital importance, and he had found that when using a certain type of moulding machine the number of rams applied was the controlling feature in the production of a good casting. He had in mind some sort of mould hardness tester, but he under-

stood that such accessories were not yet very satisfactory, as so many variables had to be considered.

More About Silt Control

MR. G. E. FRANCE said there had been a dearth of information relating to the effective operation of mechanised foundry plants, particularly in relation to sand preparation and handling. He hoped that as the result of the Paper other members of the Institute would be persuaded to give further information which would be helpful not only to operators, but also to designers of foundry plant. The efficient design and development of foundry equipment was very largely in the hands of the foundrymen themselves, inasmuch as the designers had to rely on the experience of the users of the plant.

With regard to the silt problem, nothing had been said in the Paper or in the discussion to disprove that excess of silt had a very deleterious effect on the efficiency of moulding sand. There were both manufacturers and users of foundry equipment who attached considerable importance not necessarily to the elimination of silt, but to the inclusion in their plant of some apparatus which would control the amount of silt, for they recognised the danger of uncontrolled silt. Much work had been done, and was still being done, in that direction. The remarks of Mr. Shepherd and Mr. Gardom concerning the methods used for the air separation of silt would suggest that perhaps they were not fully aware of late developments. The provision of an exhaust fan at the knock-out or at the bucket elevator was too haphazard. The problem of dust extraction should be tackled as a problem by itself. The dust and steam problem at the knock-out should be regarded purely as a problem of ventilation; the silt problem was a separate one, and could be tackled by the provision of proper plant, built into the foundry equipment, and which would give the user complete control not only of the quantity, but also of the quality of silt removed.

Whilst hot sand might not have a very material effect in a small foundry, it became an important factor in foundries engaged on intensive mass production by means of large mechanised plant. In a continuously operated foundry which he knew of, the plant had been triplicated during the last three years, and in each case the plants were producing continuously throughout the whole of the 24 hours—quite a considerable amount of the total capital expended had been concerned with sand cooling. Each unit was dealing with 60 tons of moulding sand per hour, and the sand was kept cool.

He said that Mr. Shepherd's Paper had confirmed a fact which was well known by the users of many mechanised foundry units in this country, that it was a simple matter to arrange for the constant milling of sand at the rate of 60 or 100 tons per hour. There was no difficulty in justifying it economically.

The Economic Aspect

MR. SHEPHERD said that everybody would appreciate the indications given that a lot of time and money was being devoted to making mechanised sand handling really efficient and that there was already on the market a considerable amount of efficient apparatus. Of course, there was a limit to the amount of capital that a founder could spend on his plant. The criterion was the return on the investment, and he agreed with Mr. France that the matter must be handled from the economic point of view. He agreed that the silt problem was not so much one of complete elimination as of control of the silt, and he recalled the statement he had made in the Paper, that the amount of coal dust used should be controlled very carefully; in making that statement he had had in mind the control of the amount of silt present.

MR. G. H. PIPER, in a written communication, stated that the question of coal dust in moulding sand was an important one, and he was glad Mr. Shepherd had stressed the need for careful control, both as regards quantity and fineness, in order to avoid the extremes of burning-on and veining. The amount present could be roughly estimated from the percentage of volatile matter in the moulding sand, but he thought Mr. Shepherd would agree that the method proposed by Aptekar (Trans., A.F.A., 1934), involving carbon determinations on the sand and on the original coal dust, was the more satisfactory.

There was a need for further research on the function of coal dust in moulding sands. Experimental work by B. Hird and H. Winterton had shown that, when molten metal was poured into the mould, a smoky carbonaceous flame was produced from the coal dust, which protected the sand from the action of the molten metal. A further effect which had been found in work carried out by the British Cast Iron Research Association was that the dry strength of the sand was greatly increased after a few castings had been made in a sand containing coal dust. This was of importance in connection with synthetic moulding sands where, with certain bonding clays, the dry strength of the moulding sand was too low. In such cases control of the dry strength appeared desirable in order to avoid troubles such as sand erosion and sand washed into the mould from the bottom of the runner.

Vote of Thanks

MR. F. J. COOK, proposing a vote of thanks to Mr. Shepherd for the Paper, said he had had the privilege of being present, as the representative of the Institute, at the meeting held in America in 1922, to which Mr. Shepherd had referred. The Americans had been very enthusiastic about dealing with the sand problem. It was pleasing to note that, due to the efforts of men such as Mr. Shepherd, we in this country were nowadays well in the forefront in regard to sand testing and evaluation.

The vote of thanks was seconded by MR. SHOTTON, and carried with enthusiasm.

MR. H. WINTERTON (President of the Institute) expressed the thanks of the meeting to Mr. Ellis, who had operated the lantern, and to Mr. Lockwood, Secretary of the London Branch, for the excellent arrangements he had made for the joint meeting of the London and Birmingham Branches. It had been indeed a pleasure, he added, to attend the joint meeting of these two Branches, and the visitors were indebted to the London Branch for having them to attend and for having made such excellent arrangements for their entertainment and instruction.

A RECONSTRUCTION of the share capital of the Manganese Bronze & Brass Company, Limited, is proposed by the directors to relieve the company of its debenture liabilities and provide additional capital. It is stated that sections of the plant are becoming obsolete, and that it is imperative that considerable sums be spent within the next two years in renovation and extension of buildings and plant.

Determination of Non-Metallic Inclusions in Steel and Iron

This Paper, by E. W. COLBECK, S. W. CRAVEN and W. MURRAY, which was presented to the Autumn Meeting of the Iron and Steel Institute divides the methods for determining the amount of inclusions in steel into two classes: that in which the total oxygen content is determined and, secondly, residue methods which aim at the separation of all oxidic inclusions. In the first class the hydrogen-reduction, and the vacuum fusion or hot-extraction methods are described, whilst under the second method the acid solution, electrolytic and halogen processes are explained.

Some X-ray examinations have also been made and apart from the plain carbon steels and alloy steels cast iron has been examined. We append a summary of the authors' work on cast iron.

A short preliminary investigation into the determination of non-metallic inclusions in cast iron was undertaken. A sample of cast iron was treated by both the chlorine and the iodine methods, and it was found that the latter method gave a residue which was several times greater than that from the former. Further, the residue from the iodine treatment was readily fusible at about 900 deg. C., whilst the residue from chlorine attack behaved quite normally, and was infusible when strongly ignited. Since the sample of cast iron used contained 0.85 per cent. of phosphorus, the presence of this element in the residue after iodine attack was suspected. The readily fusible nature of this residue suggested that it might be contaminated with unattacked Fe_3P.

Both residues were therefore analysed for phosphorus and iron, and the following results were obtained:—Chlorine residue (per cent.): Fe, 0.61; P, 0.03. Iodine residue (per cent.): Fe, 4.89; P, 0.80.

TABLE I.—*Analyses of Cast-Iron Residues after Chlorine and Iodine Attack.*

Cast Iron.	Residue after Chlorine Attack.		Residue after Iodine Attack.		Remarks.
	Fe. %.	P. %.	Fe. %.	P. %.	
A	0·07	0·036	0·16	0·038	No indication of Fe_3P in either case. Both residues infusible.
B	0·28	0·045	2·49	0·432	Phosphorus largely retained in iodine residue. Iodine residue fusible. Chlorine residue infusible. Iron and phosphorus present in iodine residue approximately in proportions required to form Fe_3P.
C	0·54	0·057	5·81	1·14	As for *B*.

The large preponderance of iron and phosphorus in the iodine residue is at once obvious. Practically the whole of the phosphorus originally present in the iron remains behind in the iodine residue. If the iron found in the chlorine residue is subtracted from the iron found in the iodine residue, the balance of iron remaining is approximately the amount required to combine with the phosphorus to form Fe_3P.

Balance of iron in iodine residue (per cent.), 4.28; amount of phosphorus required to combine with this iron, 0.79; actual amount of phosphorus in the iodine residue, 0.8.

These results indicated that iodine does not attack Fe_3P, but the compound is broken down by chlorine. Further proof of this was sought, three cast irons of the following analysis being examined by both methods of attack:—

Cast iron.	A.	B.	C.
Total carbon (per cent.)	3.15	2.91	3.08
Silicon (per cent.) ..	1.11	2.05	1.90
Sulphur (per cent.) ..	0.034	0.067	0.043
Phosphorus (per cent.)	0.056	0.55	1.41
Manganese (per cent.)	0.58	1.00	0.52

(*Concluded on page* 402.)

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Malleable Cast Iron

ITS PLACE IN MODERN INDUSTRY

At a meeting of the Staffordshire Iron and Steel Institute, held at Birmingham on October 27, MR. C. HUBERT PLANT read a Paper on "Malleable Cast Iron," in the course of which he reviewed the early history of the material, including its growth as an industry. Coming to present-day practice, the author said that so far as could be ascertained there were only 85 firms directly producing malleable cast iron, and of those 36 were located in the Midlands. While no exact figure was available, the tonnage of both white-heart and black-heart castings at present being produced was about 70,000 tons per annum. As a matter for comparison, the number of foundries engaged on the production of malleable cast iron in the United States at the present time was about 108, and the output for the last twelve months had been 605,750 tons, in addition to which it was estimated that approximately another 100,000 tons was accounted for by firms who were producing for their own consumption, and for other purposes, so that it would be seen the industry in America was about ten times the magnitude of that in this country. These figures were the more remarkable in that, having removed two large outputs in this country, there were only 25 per cent. more in the business in America, with an output of 14 times greater. That showed particularly well that in America the output of the average works was far in excess of the average in this country.

Use of Steel in the Mixture

Due to the absolute necessity for bringing costs down, coupled with greater metallurgical knowledge (continued the author), the most outstanding manner in which white-heart founders have altered their practice is in the introduction of steel into the mixture being melted. The general opinion used to be that only mottled iron and hard scrap should be charged into the cupola, also that the carbon content of the iron should not be lower than 3.0 per cent., or even higher. Later metallurgical knowledge has proved, however, that a lower content of carbon is a decided advantage, and that it is not necessary to have more than an average of 2.5 per cent. Obviously, costs were going to be reduced considerably by using less white iron, and including steel scrap together with grey hematite if necessary, and founders were quick to act accordingly. Difficulties were, however, quickly encountered, and it was found very much more difficult to control the ordinary melting practice when these mixtures were involved. Gradually this has been overcome, and by strict control of analysis, of the metal charged and by carefully watching each step of the melting, excellent results are obtained by melting in the cupola as was ordinarily the case. Each foundry still has more or less its own ideas on the subject, but 25 or 30 per cent. of steel is a safe figure for general practice. On the other hand, if more fairly high-silicon grey pig-iron is used, it will be obvious that a higher percentage of steel scrap may be incorporated than if the bulk of the pig-iron is of the mottled or white variety. With the use of the low carbon refined pig-irons, it is essential that there shall be a balanced sulphur-manganese ratio, and care also has to be taken that the pick-up of the sulphur in the cupola shall be a minimum.

The additional care necessary in melting steel scrap/pig-iron mixtures forced founders to look for some other more reliable means of melting than by the crucible or cupola. The Balanced-Blast cupola has been and is of very great assistance to founders in allowing them to obtain proper control of their cupola practice. Additional aid was forthcoming from the Brackelsberg, Sesci, and Stein rotary furnaces. The Brackelsberg and Sesci types are fitted with pulverised fuel as a general rule, though the Brackelsberg can be adapted for oil or gas firing, while the Stein furnace is oil fired. The most popular of these furnaces appears to be the Brackelsberg. It is particularly popular in America, very popular in Germany, and is becoming more so in this country. Mention should be made in passing of the duplex and triplex processes, in which the cupola is used as the melting medium, and other furnaces, either rotary or electric, are used for the refining of the metal later. The duplex process in particular was used in France and Germany to some extent some years ago, but so far as can be ascertained there is no founder in this country who is doing so, and it appears as if the advent and perfecting of the rotary furnace has, so far as white-heart iron is concerned, caused the duplex process to lose any favour which it may have had some years ago.

Black-Heart Practice

As regards present-day black-heart practice, so far as the metal itself is concerned, the use of steel has become common practice when the iron is being melted in the air furnace, but steel is rarely used when melting is being done in the cupola or electric furnace. Pig-iron is, therefore, the raw material which makes up most of the tonnage from which American black-heart castings are made, the average analysis being:—Sulphur, 0.05 per cent. (max.); phosphorus, 0.20 per cent.; silicon, 1.0 to 2.0 per cent., and manganese, 0.75 per cent. In view of the demand for a decreased percentage of carbon, it is necessary that the content of silicon shall be high to maintain the silicon content in the product, consequently any iron containing less than 1.25 per cent. silicon is considered useless, and some founders go so far as to specify over 2.0 per cent. of this element.

There are many types of melting furnaces in vogue at the present time, but undoubtedly the two most popular are the air furnace and the rotary furnace. Latest figures show that while Germany prefers the open-hearth furnace to any other type for this class of casting, America, on the other hand, only produces about 3 per cent. of its malleable castings by this method. At the same time, Germany is slowly increasing her melting by means of the Brackelsberg furnace in the same way that America is. Direct melting by the electric furnace is almost prohibitive because of the great expenditure entailed. One foundry in this country, and two or three in America melt black-heart iron by this means, but even where the electric furnace is used directly for malleable cast iron, it is not used solely for that material, and melting costs are reduced by using the furnace part time for melting steel. The electric furnace is economically possible, however, where it is used in connection with other mediums of melting, such as with the duplex or triplex processes. The latter process, which is responsible for many thousands of tons of malleable castings in America consist of melting in the cupola, decarburising in the converter and desulphurising and deoxidising in the electric furnace, with corrections for manganese, silicon and sulphur. It must be borne in mind that this system is only practicable when very considerable tonnages are being dealt with, and for smaller outputs the duplex process has been devised and used quite considerably. Since the advent of the rotary furnace these systems have to some extent declined, and the more general method of duplexing at the present time is to melt in the cupola and then to refine and superheat by means of the rotary furnace.

Present-Day Demands

So far as the white-heart industry is concerned, it is difficult to see in what way that metal can be improved upon or altered beyond what it is at present, but there is not the least doubt that malleable founders who are making nothing but this class of casting must acknowledge the trend. They must go very carefully into analysis of mixtures, into cupola control, into annealing times and temperatures, in fact into every process connected with its manufacture. Melting methods do not promise much change either, as they can give all that is required or likely to be for some considerable time, but it is in the constitution of the metal that there seems to be every possibility it will change out of all recognition from the original type of black-heart iron introduced by Boyden.

The Symposium on Malleable Cast Iron which was held in Cleveland in January last, concluded the author, gives an indication of the trend in this direction. The whole matter really resolves itself now into heat-treatment of white cast iron, and the resultant material termed pearlitic malleable cast iron.

DISCUSSION

MR. J. V. MURRAY stated that there had been a big battle between the white-heart and black-heart makers, and the latter had won. At the same time there were definite purposes for which white-heart castings alone were suitable, and therefore there must always be a certain demand for this class of metal. He referred to the future of annealing practice, and asked in what way Mr. Plant thought packing would alter, if at all. He had had experience of treating old ore so that it could be used again and again as if it were new ore, and very good results had been obtained by means of this practice. He did not think it was generally known, but malleable cast iron could be heat-treated just the same as steel, and in many cases he had been able to use metal by a process of heat-treatment which might not have been suitable otherwise. He was of the opinion that white-heart founders should always have a small and well-equipped test house, in which the physical properties of their product could be tested.

MR. T. G. BAMFORD said Mr. Plant had not mentioned anything about superheating. He understood that at the present time it was considered essential that the metal should be superheated and would like to know if this was so. He referred to a recent Russian contribution on present-day malleable cast-iron practice, which stated that of a number of melting media, the Brackelsberg furnace had proved to be the best and the electric furnace the worst. This publication also referred to gases in malleable cast iron, and stressed the importance of a knowledge of the effects of these, in exactly the same manner as they were considered of importance in steelmaking.

The AUTHOR, in reply to Mr. Murray, said he did not agree that there had been any battle between black-heart and white-heart makers. There had been, and still was, healthy competition between the two classes of castings, though he agreed that there were certain purposes for which white-heart iron was particularly suitable. With regard to the future of annealing, he saw no reason why packing should alter at all—it seemed that iron oxide would always be necessary for white-heart castings, and there appeared no reason to alter the inert packing materials used for black-heart castings, subject to alterations in the constitution of this metal as had been outlined. He agreed that ore could be treated so that it could be used several times, but he doubted if the ultimate saving was very pronounced. With reference to the heat-treatment of malleable cast iron, this was certainly probable, but he would never recommend it unless it was an absolute necessity, from the standpoint of extra cost. Obviously, the resulting material could be no better than steel, which, in view of the heat-treatment costs for malleable iron, would then probably be as cheap, or cheaper, than the latter metal. He did agree with the superheating of the metal, but care had to be taken, otherwise there was a risk of oxidation, which was, of course, very detrimental to the resultant casting. He had not seen the Russian publication to which Mr. Bamford referred, and was surprised to learn that it considered the electric furnace to be the worst melting medium. This was generally considered the best, theoretically and practically, the only objection to it being the high cost and the cost of upkeep.

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The Week's News in Brief

Trade Talk

THE L.N.E.R. is to construct 121 new locomotives during 1937.

SCOTTISH SHIPBUILDERS have received orders for 30 ships since the beginning of October.

A 7,500-TON CONSIGNMENT of Russian pig-iron has arrived at Glasgow for Lanarkshire steelworks. It has been bought under the agreement between British manufacturers and Russia, and is the third cargo to arrive within recent weeks.

THE STRIKE which affected production at the West Works of the Austin Motor Company, Limited, Longbridge, Birmingham, from Wednesday last week was settled last Monday, on the understanding that the management undertakes an inquiry into the workers' complaints.

AN EXTRAORDINARY general meeting of the Bengal Iron Company, Limited, will be held at the Hotel Victoria, London, on December 2, to consider special resolutions for the voluntary winding-up of the company and the carrying into effect of the merger agreement with the Indian Iron & Steel Company, Limited.

THE STAVELEY COAL & IRON COMPANY, LIMITED, announce that following the success which has resulted from the introduction of their 3-in. and 4-in. diameter metal spun pipes, they have decided to extend their plant to produce 6-in. diameter pipes of this type. Manufacture has now commenced. They will also be in a position to supply the 4-in. diameter in 18-ft. lengths by January next.

THE RECENT OFFER FOR SALE by General Refractories, Limited, of 514,000 of the International Diatomite Company, Limited, shares was heavily oversubscribed. The International Diatomite Company was incorporated in March, 1935, for the purposes of developing and marketing Diatomite, also known as Kieselguhr and Infusorial Earth. Diatomite, an unusual form of hydrated amorphous silica, is exceptionally light, porous and heat-resisting.

THE DEPARTMENT OF OVERSEAS TRADE has been notified by Earl's Court, Limited, that, owing to unforeseen circumstances, the new exhibition buildings in course of construction at Earl's Court will not be completed in time to permit of them being utilised for certain sections of the British Industries Fair, to be held from February 15 to 26 next. The Department of Overseas Trade announce, therefore, that the London sections of the Fair will be held at Olympia and the White City, as was the case this year.

THE TEES IRONWORKS of Pease & Partners, Limited, which have stood idle for eight years, are to be dismantled and the site cleared. The whole of the plant, which comprises three blast furnaces built about 1870, ten hot-blast stoves, nine calcining kilns, eight boilers and four blowing units, has been acquired for demolition by G. R. Colwell, Limited, iron and steel merchants and dismantling contractors, of Middlesbrough. It is estimated that about twelve months' work will be provided for 50 men in dismantling the plant and clearing the site, which will thereafter be available for other industrial purposes.

Iron and Steel Output

The British Iron and Steel Federation reports that there were 113 furnaces in blast at the end of October in the United Kingdom, four having been blown in during the month, and two put out of operation. The production of pig-iron in October amounted to 670,300 tons compared with 650,800 tons in September and 544,300 tons in October, 1935: the month's production includes 155,000 tons of hematite, 376,800 tons of basic, 113,200 tons of foundry and 10,300 tons of forge pig-iron. The production of steel ingots and castings in October amounted to 1,060,500 tons compared with 1,027,000 tons in September, 1936, and 907,300 tons in October, 1935.

MR. CHARLES S. GILL has been appointed to the position of commercial manager of Davy Bros., Limited, of Sheffield.

Personal

MR. DANIEL SHARPE has changed his private address to 44, Keir Street, Pollokshields, Glasgow, S.1. His telephone number is Queen's Park 2463.

SIR HARRY D. MCGOWAN, chairman and managing director of Imperial Chemical Industries, Limited, left England on November 11, on a visit to Australia and New Zealand. He expects to return to England about the middle of March.

MR. PETER WRIGHTSON has been appointed works engineer at the Teesdale Ironworks of Head Wrightson & Company, Limited, Thornaby-on-Tees. Mr. Wrightson served part of his apprenticeship in Germany, and only recently returned to this country.

SIR FRANCIS JOSEPH, C.B.E., is visiting the British Empire Exhibition at Johannesburg as the representative of the Federation of British Industries. He is a director of the London Midland & Scottish Railway, chairman of Settle, Speakman & Company, and the founder of the Central Pig-Iron Producer's Association.

MR. J. H. FREEBOROUGH has been elected chairman of Metal Heat Treatment, Limited, Sheffield, in succession to the late Mr. John Allen. Mr. Freeborough, who was already on the board of the company, is also a director of the British Time Recorder Company, Limited, Henry Rogers, Sons & Company, Limited, and other companies.

THE LORD MAYOR OF MANCHESTER (Alderman Joseph Toole, J.P.) draws our attention to the inaccuracy of our statement that he is connected with the West End Iron Works of Oldham. Actually his profession is that of a publicity agent. In his letter to us the Lord Mayor points out that when he recently met Alderman Joseph Toole, of Oldham, they concluded that they were the only two aldermen in the country bearing the name of Joseph Toole.

MR. ROBERT ARMITAGE recently completed forty years as chairman of Brown, Bayley's Steel Works, Limited, Sheffield. Mr. Armitage is a former Member of Parliament for Leeds Central, and was Lord Mayor of Leeds in 1904. He is chairman of the Yorkshire Electrical Power Company. His other directorships include those of Brodsworth Main Colliery Company, Limited, Doncaster Collieries Association, Limited, Electrical Distribution of Yorkshire, Limited, Hickleton Main Colliery Company, Limited, and Markham Main Colliery, Limited. Mr. Armitage is managing director as well as chairman of Brown, Bayley's Steel Works, Limited, and has been on the board of directors since 1890.

Will

BAKER, JOHN KIRK, of Sheffield, a director of John Baker & Sons, Limited, steel and tool manufacturers £8,570

Obituary

MR. W. F. BROTHERTON, one of the London representatives of Stewarts & Lloyds, Limited, has died at the age of 67.

THE DEATH OCCURRED on November 13 of Mr. John C. Mathieson, cashier, of Dobbie, Forbes & Company, Limited, stove and range makers, Larbert, with whom he had served for about 40 years. He was 65 years of age.

Contracts Open

Belfast, November 30.—Iron castings: malleable iron and steel; bolts and nuts, for the Belfast Harbour Commissioners. Mr. M. J. Watkins, general manager and secretary, Harbour Office.

Cardiff, November 21.—Steel pipes and specials, cast-iron or spun-iron pipes and special castings, for the Town Council. Mr. N. J. Peters, water engineer and manager, City Hall.

South Shields, November 26.—Cast-iron work and iron and steel, for the Town Council. Mr. H. Ayrey, town clerk, Town Hall.

Wembury, November 26.—5,900 yds. of 4-in. and 3-in. dia. cast-iron water mains, etc., for the Plympton St. Mary Rural District Council. The Engineer, Council Offices, Plympton. (Fee £2 2s., returnable.)

Determination of Non-Metallic Inclusions in Steel and Iron

(*Concluded from page* 398.)

Iron and phosphorus were determined on every residue, and the results are shown in Table I.

The above results are further evidence of the comparative insolubility of Fe_3P in iodine, and the breaking down of this compound by chlorine. Although the amount of phosphorus remaining in the chlorine residues increases slightly as the phosphorus content of the iron increases, there is no evidence of the presence of Fe_3P, since the residues are infusible when ignited. This confirms the work carried out by Wasmuht. It is suggested that no Fe_3P was present in the iodine residue from cast iron A, because the phosphorus content of this iron was within the solubility range of phosphorus in a cast iron of this composition. X-ray methods were made use of to confirm the conclusions arrived at by chemical methods. The residues after chlorine and iodine treatment of cast irons A and C were therefore examined by X-ray methods. The results obtained are outlined below.

Cast Irons A and C. Chlorine Residues from Treatment at 300 deg. C.—A good deal of amorphous material was present, together with a few sharp crystalline reflections. These reflections were not very strong compared with the background intensity, showing that the proportion of crystalline material was not large (probably less than 50 per cent.). Most of the lines were reflections from graphite crystals, but two weak lines did not belong to the graphite pattern. The origin of these lines is unknown.

Cast Iron A. Iodine Residue.—The residue was largely crystalline, but all the lines were graphite reflections. Some amorphous material was also present, but the proportion was not great.

Cast Iron C. Iodine Residue.—The X-ray photograph showed the presence of crystalline graphite, together with a tetragonal crystal having $a_0 = 9.08$ Å, $c_0 = 4.447$ Å. According to Hägg, Fe_3P is a tetragonal crystal with $a_0 = 9.09$ Å and $c_0 = 4.446$ Å.

From these experiments it seems probable that when Fe_3P is present in cast iron it is unattacked by iodine and is broken down by chlorine. This is not in agreement with the evidence of Lundell, Hoffman and Bright. The X-ray analyses carried out indicate that, apart from graphite, the non-metallic inclusions are probably present in the residue in the amorphous state after chlorine and iodine treatment.

Company Reports

Electric Furnace Company, Limited.—Interim dividend of 2½ per cent.

Guest, Keen & Nettlefolds, Limited.—Interim dividend on the ordinary stock of 2½ per cent., free of tax.

International Nickel Company of Canada, Limited.—Net profit for the third quarter of 1936 of $9,572,106, equivalent to 62 cents a share on the common stock after allowing for preferred dividend.

Forthcoming Events

NOVEMBER 27.

Institute of Metals (North-East Coast Section):—"Refractories," Paper by Dr. J. W. Mellor, D.Sc., at the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-upon-Tyne, at 7.30 p.m.

Institute of British Foundrymen

NOVEMBER 21.

Newcastle-upon-Tyne Branch:—"Estimating for the Foundry," Paper by C. M. White, at Neville Hall, Westgate Road, Newcastle-upon-Tyne, at 6.15 p.m.

NOVEMBER 28.

East Midlands Branch:—"More Non-Ferrous Problems," Paper by F. Dunleavy, at Loughborough College, Loughborough, at 6 p.m.

The Institute of Vitreous Enamellers

NOVEMBER 26.

Scottish Section:—"Cast Iron for Enamelling Purposes," Paper by G. M. Logan, at the Royal Technical College, Glasgow, at 7.30 p.m.

THE "ROCKET" CORE MAKING MACHINES

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REDUCE COSTS AND MAKE SOUND CASTINGS

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GREY IRON FOUNDERS
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Raw Material Markets

Every effort is being made by makers of iron and steel to comply with their contractual commitments, and in this they are generally successful. There is no surplus material, however, and the demands of export consumers are difficult to meet. While this is inevitable, it remains a source of concern to both merchants and producers, who fear that business will be permanently lost. The question of prices was considered at a meeting of the Central Pig-iron Producers' Association held last week, but no alterations have been announced. In some areas makers of both pig-iron and hematite are demanding premiums over and above the standard rates.

Pig-Iron

MIDDLESBROUGH.—Producers of Cleveland foundry pig-iron continue to exercise considerable care in the distribution of supplies. It is claimed that all regular users are receiving adequate tonnages to allow them to continue normal operations, but no export business can be entertained. Prices are unchanged and are nominal. No. 3 Cleveland G.M.B. is quoted at 75s. per ton in the Middlesbrough or Falkirk areas, 77s. on the North-East Coast, and 78s. on Clydeside. It is almost certain that these figures will be raised sooner or later, as costs of production are increasing.

Although the output of hematite on the North-East Coast is at record levels, deliveries are overdue and users would welcome the opportunity of placing further orders. Almost the whole production is fully sold up to the end of February. It is likely that increased prices will rule for deliveries thereafter. Present quotations of East Coast mixed numbers are as follow:—85s. per ton for delivery on the North-East Coast, 90s. 6d. delivered Sheffield, 96s. delivered Birmingham, and 82s. 6d. delivered South Wales. In existing circumstances these prices are more or less nominal.

LANCASHIRE.—Deliveries of pig-iron are on a good scale. Most producers have fully disposed of their outputs as far as they are willing to transact business. The makers of machine tools are active and are taking up heavy supplies of pig-iron, while satisfactory conditions are also reported from the light-castings manufacturers, heavy electrical concerns, general engineers, jobbing founders, and by several of the specialised branches of the trade. Offers of Derbyshire and Staffordshire grades of No. 3 foundry iron are on the basis of 83s. per ton for delivery to users in the Lancashire price zone, with Northamptonshire at 81s. 6d. and Derbyshire forge iron at from 78s. to 80s., according to the class of consumer. There is a fairly good inquiry for hematite. Scottish No. 3 iron is quoted at around 93s. 6d., West Coast hematite at 93s. 6d. and East Coast material at 93s., all delivered equal to Manchester.

MIDLANDS.—There is a definite shortage of Northamptonshire pig-iron, which is well taken up by the light-castings founders. A good inquiry is also experienced for Derbyshire iron. Prices are unchanged, but the figure quoted for Northants iron is purely nominal, as there are no sellers of this material. Further, a premium of 5s. per ton has been demanded by some makers. The minimum Association prices, delivered to Birmingham and Black Country stations, are 77s. 6d. for Northants No. 3 and 80s. for Derbyshire, Lincolnshire and Staffordshire No. 3. Heavy-castings makers are taking up large supplies of special irons, the prices of which are without control and vary within wide limits. Refined pig is quoted at from £6 5s. to £7 10s., low-phosphorus iron, including Scottish, at 92s. 6d. to 100s., and medium-phosphorus at from 82s. 6d. to 90s., delivered South Staffordshire.

There is little possibility of securing additional supplies of hematite at the present time. Producers are fully occupied in keeping pace with existing contracts. Any new business that is accepted is at a premium of 5s. to 10s. per ton on standard charges. Prices are nominal at £4 17s. for West Coast mixed numbers, £4 16s. for East Coast No. 3 and £4 15s. 6d. for Welsh mixed numbers, delivered stations in this area. An extra of 1s. 6d. per ton is charged if delivered to consumers' works.

SCOTLAND.—All grades of iron in this area are reported to be in short supply and consumers are having difficulty in obtaining further supplies. No. 1 foundry is still quoted at 81s. 6d. and No. 3 at 79s. f.o.t. furnaces. Quotations for Cleveland iron at 75s. f.o.t. Falkirk and 78s. f.o.t. Glasgow are purely nominal, as there is no material available. The position as far as the steelworks is concerned is still very tight. Prices of steel-making irons are unchanged at 85s., less 5s. rebate, for mixed numbers of East Coast, West Coast and Scottish hematite; 75s., less 5s. rebate, for basic, British and Indian, all f.o.t. steelworks.

Coke

There is no change to report in prices on the foundry-coke market, but it is expected that increases will be made at an early date. Any change will, however, not be immediately felt on the market, as most consumers are covered over several months. For delivery in Birmingham and district, best Durham coke is quoted at 41s. to 43s. 6d., and Welsh at from 40s. to 54s. per ton.

Steel

Great activity rules in all branches of the steel industry. In several departments the producers are unable to do more than meet current obligations and a real scarcity prevails, says the official report of the London Iron and Steel Exchange. The works producing semi-finished material are operating at capacity, but are unable to meet fully the heavy requirements of the consuming industries. The situation in this department, however, is not so difficult as that prevailing before the additional quantities of Continental semis were imported. In the finished steel section of the market all departments are working at practically full rate, and most of the works have sufficient orders on their books to enable them to maintain output at current rates for several months to come. The demand on export account has shown some improvement of late; but the British steelmakers have comparatively little available for oversea markets owing to the heavy pressure of home requirements.

Scrap

There is a good demand for all qualities of scrap on the Cleveland market and prices are firm. Supplies are not too plentiful, but have generally proved adequate to satisfy current requirements. For delivery at the steelworks 60s. per ton is paid for heavy steel scrap, while 67s 6d. and 65s. are the respective unchanged figures for heavy machinery metal and ordinary heavy foundry scrap. Clean, light cast-iron scrap is at 53s. Business on the Midland market is chiefly confined to small parcels for prompt delivery. There is a steady inquiry at firm prices. Heavy steel in furnace sizes is at 53s. 6d., which is also the price for mixed heavy iron and steel. Heavy machinery in cupola sizes is at 72s. 6d., good heavy pipe and plate at 67s. 6d. and clean light at 55s. Short, heavy steel, as used in the foundries, is at 65s. to 67s. 6d. per ton, delivered works. Active conditions are prevailing on the Yorkshire market and some large tonnages are regularly changing hands. Heavy wrought iron suitable for shearing is around 67s. 6d., with foundry cast iron at 67s. 6d. and heavy steelworks cast iron at 55s. The demand on the Scottish market remains excellent at firm quotations. First-class heavy steel scrap is at 57s. 6d., with heavy basic, or heavy iron and steel scrap mixed, 5s. per ton less. Good, clean, heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is around 70s., with heavy ordinary cast iron, to the same specification, about 5s. per ton below this figure, delivered f.o.t. consumers' works.

Metals

Copper.—Following the high prices recorded for this metal last week quotations dropped quite considerably, but the decline was checked and a further increase was noted on Friday. There is actually little change to report in the condition of the market, which remains firm. Large tonnages are changing hands and there is every prospect of a continuance of heavy buying. The opinion has been expressed in copper circles that the price is too high, that it is unnatural and entirely due to speculative movements. A figure around the £40 mark, or even lower, would be more in keeping with the true state of the market, it is claimed. Consumers in the United States are fairly well covered, but the demand is still heavy and large tonnages are going into consumption.

Daily market prices:—

Cash.—Thursday, £42 15s. to £42 17s. 6d.; Friday, £43 5s. to £43 6s. 3d.; Monday, £43 8s. 9d. to £43 10s.; Tuesday, £43 13s. 9d. to £43 15s.; Wednesday, £44 2s. 6d. to £44 3s. 9d.

Three Months.—Thursday, £43 2s. 6d. to £43 3s. 9d.; Friday, £43 12s. 6d. to £43 13s. 9d.; Monday, £43 16s. 3d. to £43 17s. 6d.; Tuesday, £44 1s. 3d. to £44 2s. 6d.; Wednesday, £44 10s. to £44 11s. 3d.

Tin.—With regard to the events in the tin market following the announcement that the output quota had been increased to 105 per cent., the weekly review of the metal markets issued by Rudolf Wolff & Company states that "this sudden announcement completely demoralised the market and the price collapsed, with relatively little business intervening. Since then, very irregular movements have occurred, but with some support forthcoming, and sellers in turn displaying a more reserved attitude, the price has recovered. Trade demand has been rather disorganised by the sharp fluctuations during the week, and business with consumers has in consequence been irregular, the tendency being, in all the uncertainty which prevails, to cover only actual requirements. In the present sensitive condition of the market, irregular movements are likely to continue, at least in the near future, but, looking further ahead, it is hoped that nothing will arise with regard to fundamental conditions to create such a disturbing effect as the recent announcements have had on the tin situation, and that the market will now be allowed to settle down and prices find their natural level."

Metal Exchange quotations were as follow:—

Cash.—Thursday, £235 15s. to £236; Friday, £239 5s. to £239 10s.; Monday, £234 10s. to £235; Tuesday, £231 10s. to £231 15s.; Wednesday, £234 5s. to £234 10s.

Three Months.—Thursday, £232 15s. to £233; Friday, £236 to £236 5s.; Monday, £232 to £233; Tuesday, £230 15s. to £231; Wednesday, £233 5s. to £233 10s.

Spelter.—Price movements in this market have reacted in sympathy with those of other metals. Following a sharp decline a recovery was noted and the tone of the market remains quite firm. It is reported that producers in this country are pressing the Government to give them additional protection with regard to import duties. Buying is on a fair scale and is expected to increase with the advent of the New Year. Conditions in the United States are active and the market is firm.

Official quotations were as follow:—

Ordinary.—Thursday, £15 8s. 9d.; Friday, £15 15s.; Monday, £15 17s. 6d.; Tuesday, £15 15s.; Wednesday, £16 2s. 6d.

Lead.—It is suggested that a quiet period will probably be experienced in this market for some time, as users generally are well covered ahead, and are likely to remain out of the market. Consumption continues to be excellent. A firm market is reported from the United States.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £20 16s. 3d.; Friday, £20 17s. 6d.; Monday, £20 15s.; Tuesday, £21 2s. 6d.; Wednesday, £21 17s. 6d.

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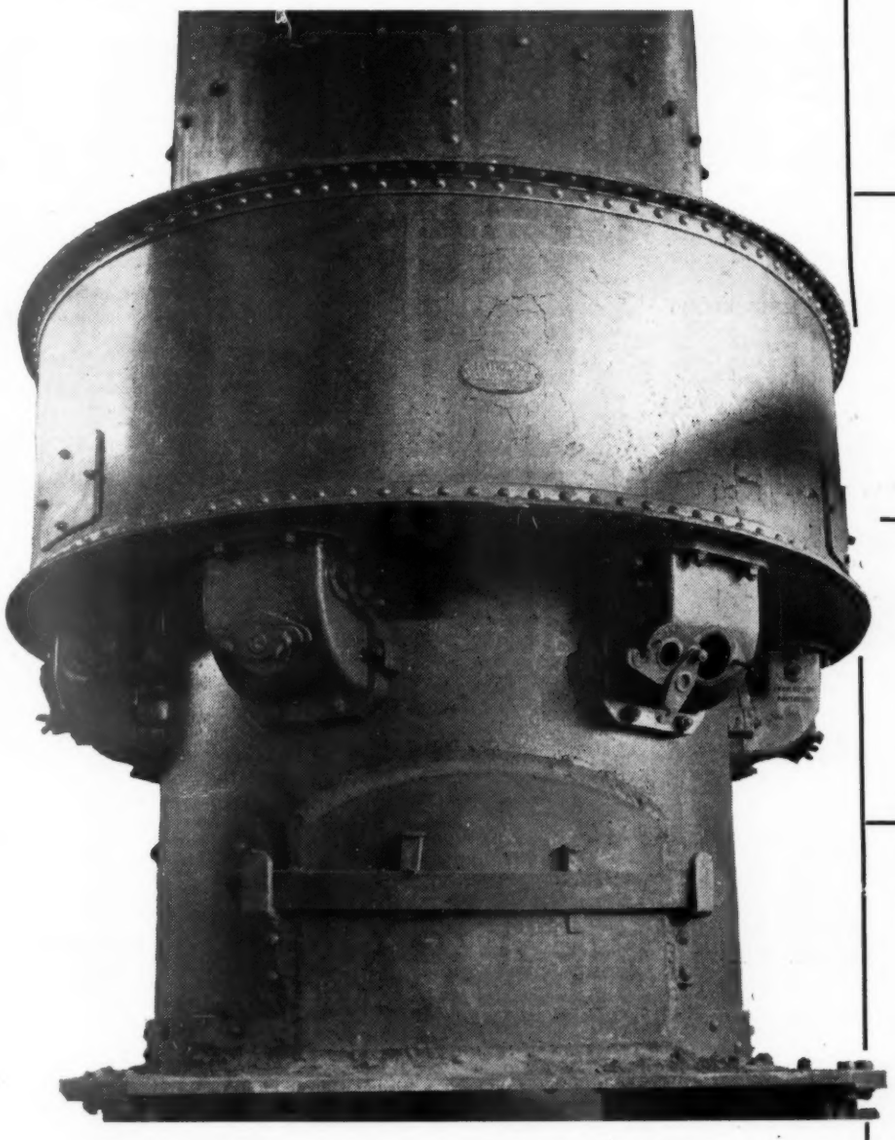
CUPOLA LININGS for Christmas Repairs

Our Works are now ready to handle production of Cupola Linings of every type to be delivered in time for your Christmas needs.

We particularly recommend our customers to order their requirements in good time to avoid any possibility of disappointment in delivery. We manufacture Linings in Scottish, Sheffield and Stourbridge Qualities, to suit different Cupola conditions.



FIREBRICKS suitable for Cupola Linings

1—GLENBOIG

Manufactured from the famous Glenboig Fireclay, this firebrick has enjoyed a world wide reputation for almost a century

2—WHITE CARR

Low porosity is essential in the case of furnace linings subjected to abrasive forces and to slag action, and in this respect White Carr Firebricks have proved to be particularly valuable

3—DYKEHEAD

Since 1916 Dykehead bricks have been enjoying an ever increasing reputation for uniformity of fine quality

4—STOUR

Stour firebricks are capable of withstanding very high temperatures without melting or splitting and where sudden changes of temperature have to be contended with, are unsurpassed

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RAW MATERIALS—PRICE LIST

(Wednesday, November 18, 1936)

COPPER

	£ s. d.
Standard cash	44 2 6
Three months	44 10 0
Electrolytic	48 10 0
Tough	46 15 0
Best selected	47 5 0
Sheets	75 0 0
India	57 10 0
Wire bars	48 10 0
Ingot bars	48 10 0
H.C. wire rods	52 0 0
Off. av. cash, Oct.	41 0 4 1/2
Do., 3 mths., Oct.	41 3 10 1/4
Do., Sttlmnt., Oct.	41 0 5
Do., Electro, Oct.	45 10 6
Do., B.S., Oct.	45 0 10
Do., wire bars, Oct.	45 15 1
Solid drawn tubes	11½d.
Brazed tubes	11½d.
Wire	7¼d.

BRASS

Solid drawn tubes	10½d.
Brazed tubes	12½d.
Rods, drawn	9½d.
Rods, extd. or rlld.	5½d.
Sheets to 10 w.g.	8½d.
Wire	8½d.
Rolled metal	8½d.
Yellow metal rods	5½d.

TIN

	£ s. d.
Standard cash	234 5 0
Three months	233 5 0
English	234 5 0
Bars	236 5 0
Straits	236 10 0
Australian	234 5 0
Eastern	232 15 0
Banca (nom.)	236 10 0
Off. av. cash, Oct.	201 7 3
Do., 3 mths., Oct.	199 2 0
Do., Sttlmt., Oct.	201 6 9

SPELTER

	£ s. d.
Ordinary	16 2 6
Remelted	14 5 0
Hard	13 5 0
Electro 99.9	18 2 6
English	16 12 6
India	14 0 0
Zinc dust	19 15 0
Zinc ashes	4 10 0
Off. aver., Oct.	14 13 10
Aver. spot, Oct.	14 11 0

LEAD

	£ s. d.
Soft foreign ppt.	21 17 6
Empire	21 17 6
English	23 15 0
Off. aver., Oct.	18 8 2
Aver. spot, Oct.	18 8 11

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	25 10 0 to 26 0 0
Do., V.M. ex-whse.	25 10 0 to 26 0 0
Rods	27 15 0

ANTIMONY

English	67 10 0 to 68 10 0
Chinese, ex-whse.	52 0 0
Crude, c.i.f.	25 15 0

QUICKSILVER

Quicksilver	14 5 0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	11 0 0 to 12 5 0
75%	16 2 6 to 17 7 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	3/1½ lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 10 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.5% car.	37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	6/3 to 6/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£11 15 0 to 12 5 0
76/80% packed	£12 15 0 to 13 5 0
76/80% export	£10 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/16 in.	1/– lb.
Flats, ¼ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ⅛ in. × ¼ in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel		3 4 0
Mixed iron and steel	3 0 0 to 3	1 0
Heavy cast iron	2 18 0 to 3	0 0
Good machinery	3 2 0 to 3	4 0
Cleveland—		
Heavy steel		3 0 0
Steel turnings		2 5 0
Heavy cast iron		3 5 0
Heavy machinery		3 7 6
Midlands—		
Light cast-iron scrap		2 15 0
Heavy wrought iron	3 5 0 to 3	7 6
Steel turnings		2 0 0
Scotland—		
Heavy steel		2 17 6
Ordinary cast iron	3 4 0 to 3	5 0
Engineers' turnings		2 2 6
Cast-iron borings		1 17 9
Wrot-iron piling		3 10 0
Heavy machinery		3 10 0

London—Merchants' buying prices, delivered yard.

Copper (clean)	36 0 0
Brass	22 0 0
Lead (less usual draft)	18 10 0
Tea lead	14 10 0
Zinc	9 0 0
New aluminium cuttings	74 0 0
Braziery copper	34 0 0
Gunmetal	35 0 0
Hollow pewter	155 0 0
Shaped black pewter	118 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
,, No. 3	75/–
,, No. 4	74/–
Forge No. 4	74/–
Hematite No. 1	85/6*
Hematite M/Nos.	85/–*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
,, d/d Birm.	97/–*
Malleable iron d/d Birm.	125/–
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/–
,, No. 3 fdry.	80/–
Northants forge	74/6
,, fdry. No. 3	77/6
,, fdry. No. 1	80/6
Derbyshire forge	77/–
,, fdry. No. 3	80/–
,, fdry. No. 1	83/–
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/–
Cleveland No. 3, Glasgow	78/–
,, ,, Falkirk	75/–
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
,, fdry. No. 3	77/6
Lincs forge	74/6
,, fdry. No. 3	77/6
W.C. hematite	91/–*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/–
Staffs fdry. No. 3	83/–
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/–
Dalzell, No. 3 (special)	102/6 to 105/–
Glengarnock, No. 3	93/6
Clyde, No. 3	93/6
Monkland, No. 3	93/6
Summerlee, No. 3	93/6
Eglinton, No. 3	93/6
Gartsherrie, No. 3	93/6
Shotts, No. 3	93/6

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)		10 10 0
Nut and bolt iron	8 17 6 to 9	7 6
Hoops	11 7 6 and up.	
Marked bars (Staffs) f.o.t.		13 0 0
Gas strip	11 7 6 and up.	
Bolts and nuts, ¼ in. × 4 in.		16 0 0 and up.
Steel—		
Plates, ship, etc.	9 7 6 to 9	10 0
Boiler plts.	9 17 6 to 10	0 0
Chequer plts.		11 0 0
Angles		9 0 0
Tees		10 0 0
Joists		9 7 6
Rounds and squares, 3 in. to 5½ in.		10 0 0
Rounds under 3 in. to ⅜ in. (Untested)		9 7 0
Flats—8 in. wide and over		9 5 0
,, under 8 in. and over 5 in.		9 10 0
Rails, heavy	8 5 0 to 8	10 0
Fishplates		12 10 0
Hoops (Staffs)		10 2 0
Black sheets, 24g. (4-t. lots)		12 0 0
Galv. cor. shts. (,,)		14 0 0
Galv. flat shts. (,,)		14 10 0
Galv. fencing wire, 8g. plain		15 0 0
Billets, soft		6 2 6
Billets, hard	7 2 6 to 7	7 6
Sheet bars		6 0 0
Tin bars		6 0 0

PHOSPHOR BRONZE

Per lb. basis

Strip	11d.
Sheet to 10 w.g.	12d.
Wire	13½d.
Rods	12½d.
Tubes	14½d.
Castings	12½d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

Per lb.

Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.88
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	32.00
Sheet bars	32.00
Wire rods	40.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	2.05
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.60
Sheets, galv., No. 24	3.20
Wire nails	2.05
Plain wire	2.50
Barbed wire, galv.	2.55
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/– to 32/–
,, furnace	24/6 to 25/–
Durham foundry	24/6
,, furnace	21/6
Scotland, foundry	30/–
,, furnace	25/– to 26/–

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	18/9
,, 28×20 ,,	37/6
,, 20×10 ,,	27/–
,, 18¾×14 ,,	19/6
C.W. 20×14 ,,	15/9
,, 28×20 ,,	34/–
,, 20×10 ,,	22/9
,, 18⅞×14 ,,	15/9

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£25 0 0 to £28 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.	
Nov. 12 ..	42	15	0 dec.	16/3
„ 13 ..	43	5	0 inc.	10/–
„ 16 ..	43	8	9 „	3/9
„ 17 ..	43	13	9 „	5/–
„ 18 ..	44	2	6 „	8/9

Electrolytic Copper

	£	s.	d.	
Nov. 12 ..	47	0	0 dec.	30/–
„ 13 ..	47	10	0 inc.	10/–
„ 16 ..	47	15	0 „	5/–
„ 17 ..	48	0	0 „	5/–
„ 18 ..	48	10	0 „	10/–

Standard Tin (cash)

	£	s.	d.	
Nov. 12 ..	235	15	0 inc.	75/–
„ 13 ..	239	5	0 „	70/–
„ 16 ..	234	10	0 dec.	95/–
„ 17 ..	231	10	0 „	60/–
„ 18 ..	234	5	0 inc.	55/–

Tin (English ingots)

	£	s.	d.	
Nov. 12 ..	236	0	0 inc.	70/–
„ 13 ..	239	5	0 „	65/–
„ 16 ..	235	0	0 dec.	85/–
„ 17 ..	231	10	0 „	70/–
„ 18 ..	234	5	0 inc.	55/–

Spelter (ordinary)

	£	s.	d.	
Nov. 12 ..	15	8	9 dec.	12/6
„ 13 ..	15	15	0 inc.	6/3
„ 16 ..	15	17	6 „	2/6
„ 17 ..	15	15	0 dec.	2/6
„ 18 ..	16	2	6 inc.	7/6

Spelter (Electro, 99.9 per cent.)

	£	s.	d.	
Nov. 12 ..	17	10	0 dec.	11/3
„ 13 ..	17	15	0 inc.	5/–
„ 16 ..	17	17	6 „	2/6
„ 17 ..	17	15	0 dec.	2/6
„ 18 ..	18	2	6 inc.	7/6

Lead (soft foreign, prompt)

	£	s.	d.	
Nov. 12 ..	20	16	3 dec.	8/9
„ 13 ..	20	17	6 inc.	1/3
„ 16 ..	20	15	0 dec.	2/6
„ 17 ..	21	2	6 inc.	7/6
„ 18 ..	21	17	6 „	15/–

Lead (English)

	£	s.	d.	
Nov. 12 ..	22	15	0 dec.	10/–
„ 13 ..	22	15	0 No	change
„ 16 ..	22	15	0 „	„
„ 17 ..	23	0	0 inc.	5/–
„ 18 ..	23	15	0 „	15/–

Imports and Exports of Pig-iron, Castings, etc., in October and the Ten Months 1936, compared with October and the Ten Months 1935.

	October.		Ten months.		October.		Ten months.	
	1935.	1936.	1935.	1936.	1935.	1936.	1935.	1936.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	3,850	11,777	57,845	106,110	11,457	37,076	172,064	333,520
„ Foreign Countries	2,056	11,696	13,041	90,070	11,730	40,911	76,346	310,427
Total	5,906	23,473	70,886	196,180	23,187	77,987	248,410	643,947
Castings and forgings	317	467	2,618	5,771	11,339	15,608	71,744	201,081
Cast pipes and fittings	247	133	1,450	1,286	6,479	3,892	36,980	42,055
Stoves, grates, etc.	84	63	994	648	6,552	4,135	81,688	60,092
Baths	531	952	5,796	6,785	14,145	22,333	153,922	164,902
Hollow-ware, all kinds	248	290	2,155	3,022	15,090	16,180	142,008	162,367
Exports.								
Pig-iron, forge and foundry	7,852	3,541	78,590	47,359	26,484	16,414	273,035	183,024
„ acid	5,486	5,583	42,447	35,815	17,710	21,632	137,255	131,359
„ basic	10	4	829	152	36	17	2,650	810
Total	13,348	9,128	121,866	83,326	44,230	38,063	412,940	315,193
Castings and forgings	262	275	3,601	3,323	10,429	10,164	138,919	125,159
Cast pipes and fittings, up to 6 in. diameter	5,207	5,027	48,881	47,602	61,195	58,201	546,133	533,782
„ „ „ „ over 6 in.	2,116	3,372	28,091	32,401	23,241	28,225	228,276	265,407
Stoves, grates, etc.	1,013	1,116	7,315	8,689	52,507	53,326	371,047	437,798
Sanitary cisterns	271	280	2,564	2,515	8,336	8,271	75,463	77,591
Bedsteads, including tubes therefor	513	522	3,731	4,142	17,325	18,499	136,410	152,082
Cast hollow-ware	579	564	3,522	4,587	19,528	19,218	131,489	165,443

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13, RUMFORD STREET, LIVERPOOL.

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IRON

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

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ZETLAND ROAD, MIDDLESBROUGH.

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

FOUNDRY Foreman desires change. Broad experience with machine-tool and general engineering castings up to 30 tons; modern production methods; practical and technical training. Real live man. M.I.B.F.—Box 964, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

NON-FERROUS Foundry Foreman seeks engagement. 14 years experience in Admiralty Contracts, Gunmetal, Phos. Bronzes. —Box 990, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

COREMAKER wanted by Staffordshire firm of Ironfounders. Man used to good class medium cores required. Continuous employment. Reply giving age, experience, and terms required, to Box 966, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

ASSISTANT wanted for Estimating and Sales Department of Foundry and Engineering Works in London. Some previous experience of similar work is necessary. Apply giving full particulars of age, training and experience, to Box 102, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

CHARGE-HAND for Iron and Steel Foundry wanted. Excellent opportunity for keen, energetic man with progressive firm. Applicants must not be under 26 years of age and must have had good moulding experience in general iron or steel castings. Some technical knowledge an advantage. State all relevant particulars, which will be treated confidentially, to Box 992, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

LANCASHIRE firm, specialising in medium and light castings, requires thoroughly competent Foundry Foreman, preferably under 40. Applicants must possess sound knowledge of all sections of foundry practice, and must have first-class organising and supervising ability. Only applicants meeting above requirements need apply. State full details of experience and salary required.—Box 996, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Assistant Foundry Manager; must have had practical experience in moulding for all types of iron castings and capable of taking charge, if necessary, of foundry employing about 230 men. Must also be able to fix piecework prices.—Box 100. Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED. — Experienced Cupola Man. Casting 5 to 6 tons per day. Able to do all repairs and bricking. State references and wages required to: HACKING & Co., LTD., California Iron Works, Bury.

FINANCIAL

FOUNDRY Manager making castings for the trade wishes to become financially interested in small foundry. Commercial and practical experience.—Box 998, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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MODERN Steelfoundry at Rotherham, main building 65 ft. by 150 ft. (erected 1916); complete with 10-ton crane. Site 1 acre. Siding on L.N.E. Rly. Adjacent canal.—Apply: GORDON, P.O. Box 98, Sheffield.

BUSINESS FOR SALE

IRON FOUNDRY FOR SALE.

A PROFIT-EARNING old-established Iron Foundry Business for disposal. Accountant's figures available.—Apply REDDALL, OSBORNE & Co., 1, Guildhall Chambers, Basinghall Street, London, E.C.2.

MACHINERY

REQUIRED.—Good second-hand 2-ton Overhead Electric Travelling Crane. Cupola to melt 1-2 tons per hr., complete with fan. Send full specifications to Box 994, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

CUPOLA Plant for Sale.—2 tons per hr. Thwaites-type Cupola with staging, fan, and all equipment. Now lying at Northallerton. Cheap before removal.—ALEX. HAMMOND, 14, Australia Road, Slough. 'Phone: Slough 287.

PIERCY & CO., LTD.,
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SURPLUS Foundry Plant for Sale, including Jackman Sandblast Table and Core Stoves; Tilghman Sandblast Barrels; Receiving Tank; Jackman Grinding Machine; Sand Drier; August Borrman Core Blowing Machine; Broom & Wade Air Compressor; Rotoil Sand Core Mixers, etc. Can be inspected at above address. Real bargains for quick sale.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

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Tilghman Sandblast Cabinet Plants; 4 ft. 6 in. and 3 ft. 6 in. square (one for high pressure 70 lbs. per sq. in.); also small Cabinet 30 in. dia.

All complete with Air Compressors, etc.

Gas and Air Mixer by Sharpe & Preston, 2-in. outlet.

Six Osborne Pneumatic Jolt Press Moulding Machines, size 75J.

Three Mumford Yoke Headpress Pneumatic Moulding Machines.

Two Herbert Whizzer Sand Disintegrators.

Two Brealey Type ditto.

Heavy Double-ended Grinding Machines by Rowlands, Luke & Spencer, etc.

Hand Moulding Machines by Adaptable Darling & Sellars, Pridmore, Samuelson, etc.

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No. 5 Ajax Pneumatic JOLT-RAM ROLL-OVER MOULDING MACHINE; take boxes 36" x 24".

Three LANCS. BOILERS; 30' x 8'; 140 lbs. w.p.

New O.T. self-colour CISTERNS; 4' x 4' x 4'; 400 galls.

Write for "Albion" Catalogue.

'Grams: "Forward." 'Phone: 23001 (10 lines).
ALBION WORKS, SHEFFIELD.

MACHINERY—*Continued*

'PHONE **98** STAINES.

ROBEY Vertical Air Compressor, 850 c.f. at 30 lbs. w.p.; Keith Blackman 4-in. Narrow Pattern Blower, 410 volts d.c.; Cochran Boiler, 10 ft. 3 in. by 4 ft. 9 in., 100 lbs. w.p.; 8-in. Modern Belt-driven Root's Blower.

HARRY H. GARDAM & CO., LTD.,
STAINES.

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MAY WE SAVE YOU MONEY on your pattern costs? Advice and quotations free.—GENERAL PATTERNMAKERS, 5, Fountain Street, Morley, Leeds.

FLUIDITY TESTS.—Patterns for these tests as described in F.T.J. of September 24 by Carl F. Joseph. Made in aluminium from our master pattern. 35s. per set. We shall also be glad to have your inquiries for patterns in hard or soft woods for all kinds of engineering, large and small.—FURMSTON & LAWLOR, Pattern Makers, Letchworth.

HIGH quality Castings in soft grey iron at competitive prices. Machined to instructions if required. Service and delivery guaranteed.—THE ROTHER IRONWORKS, LTD., Rye, Sussex.

GENUINE Southport Wind Blown Sand, which makes best oil-sand cores. Prompt deliveries by road into works.

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'Phone: 287 SLOUGH

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New Brealey type Sand Mixer.	Price,	**£25**
Sand Mill 4' diameter, as new.	Price,	**£28**
Large Herbert Sand Mixer.	Price,	**£44**
Very good 18-ton Ladle.	Price	**£40**

LARGE STOCK OF A.C. MOTORS, COMPRESSORS, SANDBLASTS, ETC.

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BUY FROM ME AND SAVE MONEY!